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INDUSTRIAL PROTECTION MANUAL.(U)

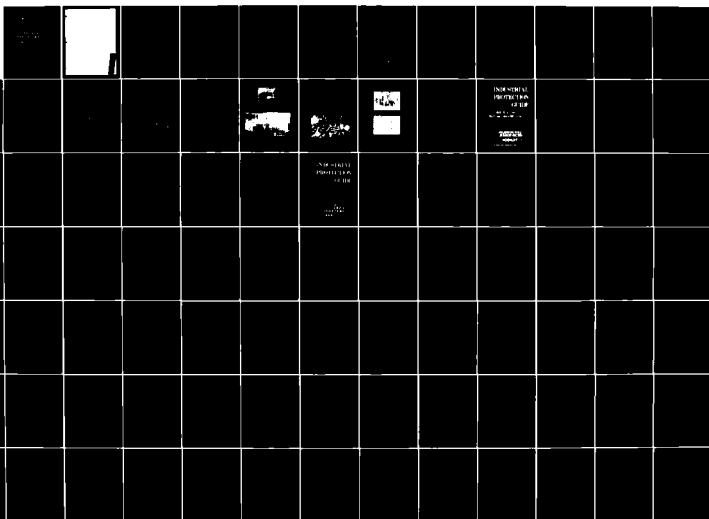
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INDUSTRIAL PROTECTION MANUAL

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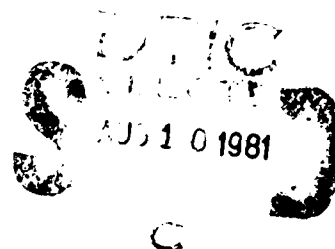
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CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

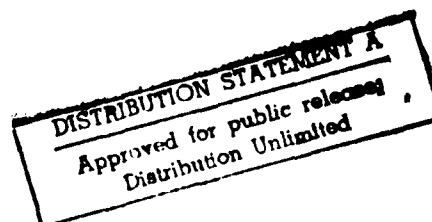
Booklet 1

MANAGEMENT PLANNING GUIDE



This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063



PREFACE

A plan to save lives and resources is presented which can be implemented subsequent to a disaster warning in 72 hours, if necessary. The plan presents three major responses:

1. Shutdown of non-essential operations and removal of irreplaceable documents, records, plant equipment, and vehicles to the safety of an emergency relocation site.
2. Preparation of an emergency relocation site to which employees and dependents would be moved during a crisis.
3. Systematic reduction in the vulnerability of plant property and equipment (called hardening).

Response is achieved through a number of different activities detailed in individual booklets.

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Booklet 1

MANAGEMENT PLANNING GUIDE

In an emergency situation, disaster planning requires attention to two problems:

- o Plant equipment and plant personnel survival
- o Post-crisis recovery and operation

This guide was developed to help you improve your company's chances for survival and recovery from a disaster. There is special emphasis in the plan on protection from nuclear threats, but many of the actions are applicable to other emergencies as well. Planning and preparation are the most important management steps that can be taken to minimize the impact of any disaster, and temporarily relocating to get out of the path of a disaster is the oldest tested response.

Current emergency preparedness strategy is based on advance warning of a threat because most natural and nuclear disasters provide advance warning. If nuclear, the disaster could be triggered by terrorists or by observation that an unfriendly power was evacuating cities. (The latter case is expected to provide three or more days warning to act.) If a natural disaster, warnings range from several hours to three days (e.g., tornadoes, hurricanes --- eventually even earthquakes may be predictable). Preparedness and crisis relocation are part of the emergency strategy for survival whether a natural or nuclear disaster.

Crisis relocation requires that all non-essential personnel (and everything that may be critical to rapid recovery) be moved out of designated high-risk areas when possible, and dispersed into surrounding lower-risk (host) areas for the duration of the emergency, and that everything that may be critical to rapid recovery be either hardened (protected) in place or also evacuated to low-risk areas.

There are other strategies. For example, underground school facilities in parts of the United States enable operations to continue right through a tornado or an earthquake. This same strategy is employed by the Swedes, Swiss, and the Soviets, who have built underground facilities to enable operations to continue through a nuclear crisis.

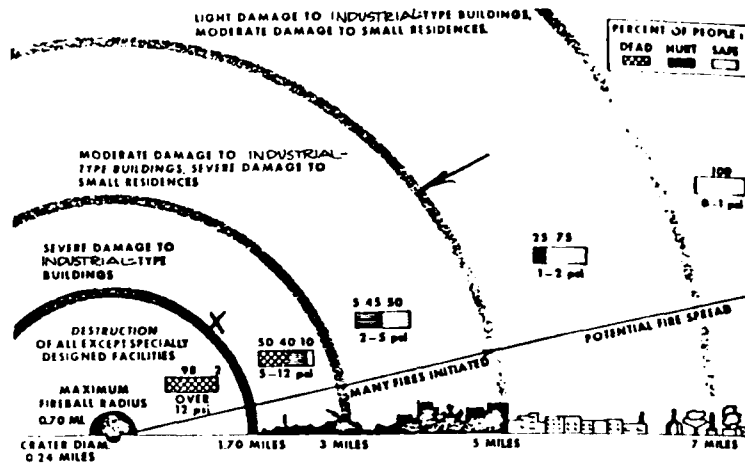
Planning for dispersal in a crisis, Crisis Relocation Planning (CRP), is being conducted at the Federal and State levels. The intent of this manual is to provide an approach that is compatible with the relocation strategy for industry to use to protect production equipment in the face of an impending crisis. Saving production equipment in addition to lives is important because production capability is critical to survival after recovery. By using advance planning, response time can be shortened so that sufficient time is available for emergency shutdown of operations and for completion of tasks that will limit the risk to equipment and facilities left behind. Early planning will enable you to marshal your resources quickly in an emergency to do this job. The underlying rationale for crisis relocation (or for location of facilities underground) is described below.

Figures 1 and 2 give a generalized picture of the immediate effects around the worst disaster, a nuclear burst; two sizes of weapon are shown. With hardening, even though most buildings inside the two rings marked with arrows would be badly damaged or demolished, protected equipment could survive outside the two rings marked X. It is estimated that with no civil defense a massive attack including many thousands of weapons such as the one shown in Figure 2 would destroy a majority of the industrial base of the country. With a viable and implemented industrial protection plan it is estimated that most of the industrial base would survive. This is more apparent in Figure 3.

In order for such a plan to work, it must have the full cooperation of industry, and industry management must realize that only by their actions can their livelihood be preserved.

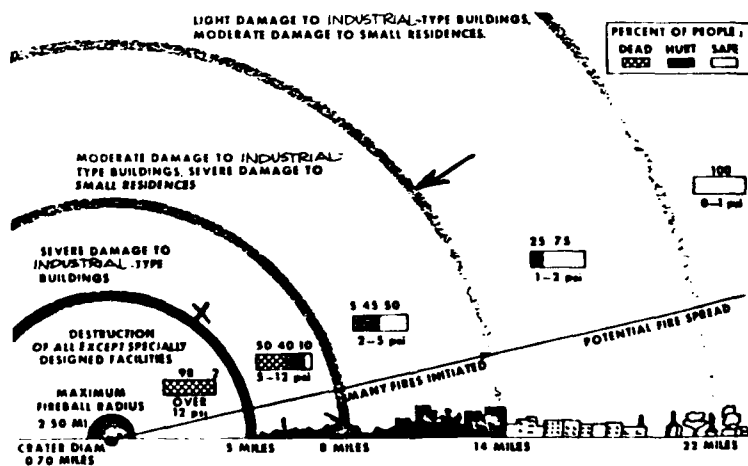
The plan presented in this manual is relatively simple to implement and is designed so that much of the planning and preparation can be done far in advance.

Figure 1. DIRECT EFFECTS OF 1 MT. BLAST
(SURFACE BURST)

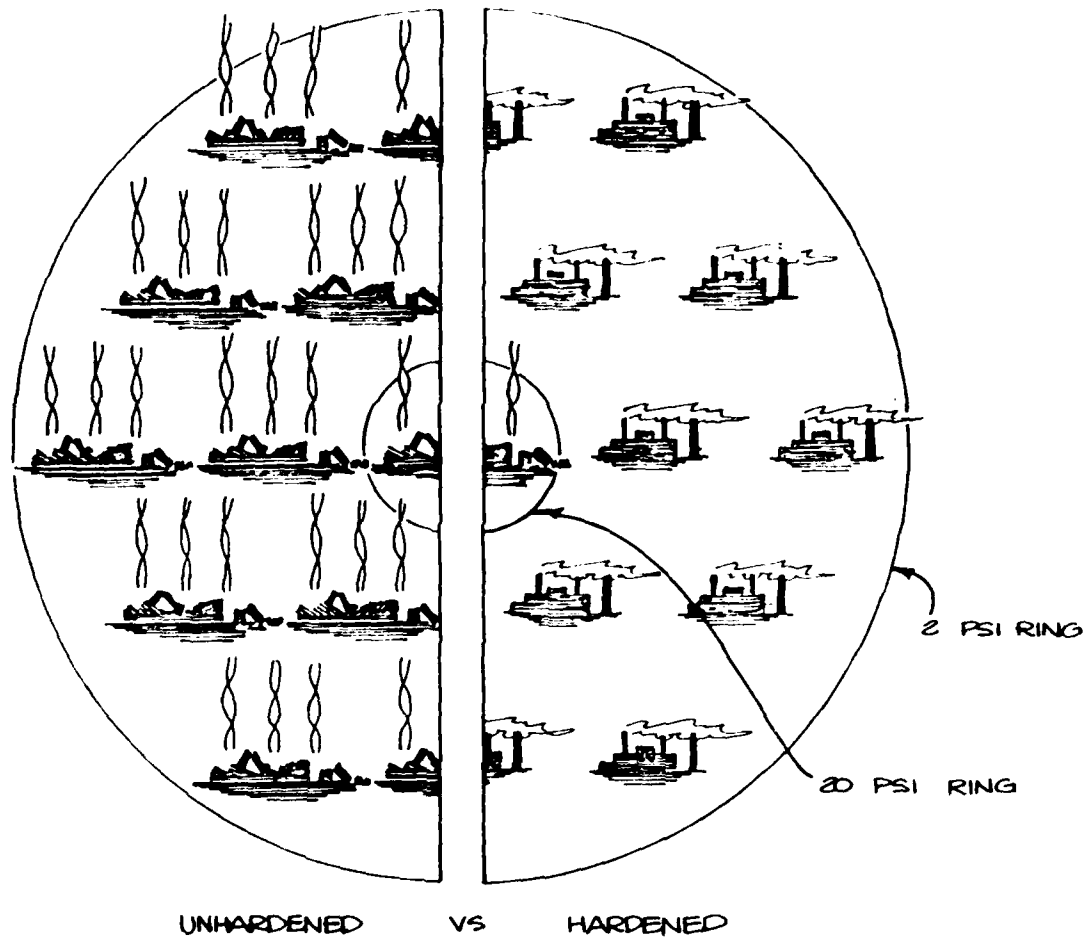


IF BURST IS ELEVATED TO ALTITUDE MAXIMIZING THE REACH OF BLAST DAMAGE, MODERATE DAMAGE FROM BLAST AND INITIAL FIRES ON A CLEAR DAY ARE EXTENDED FROM 5 MILES TO 8 MILES.

Figure 2. DIRECT EFFECTS OF 25 MT. BLAST
(SURFACE BURST)



IF BURST IS ELEVATED TO ALTITUDE MAXIMIZING THE REACH OF BLAST DAMAGE, MODERATE DAMAGE FROM BLAST AND INITIAL FIRES ON A CLEAR DAY ARE EXTENDED FROM 14 MILES TO 22 MILES.



NOTE: PLANT SYMBOLS REPRESENT DAMAGE EXPECTED OF PRODUCTION EQUIPMENT.

Fig. 3. Relative Impact of a Nuclear Attack on Production for Hardened versus Unhardened Equipment.

The plan also allows for rapid implementation in time of crisis, and for the most part is designed to use the personnel and material resources at hand. The plan, called Industrial Hardening, is presented in 10 booklets, which make up the current manual. It is expected that the overall manual will be improved on a regular basis; it can also be applied to advantage now. The various activities involved in implementing the plan are shown in Figure 4.

Industrial Hardening is anything that will reduce the vulnerability of plant or plant equipment to nuclear weapons effects (which include fire, ground motions, hurricane winds, pressure waves, electromagnetic pulse, fallout) or natural disasters. It must be done before final evacuation, and will generally require a lot of people. Your employees will be more likely to be responsive to this task if both they and you have discussed it and planned ahead. Also, if their dependents are reasonably safe and you are certain about your decisions, the hardening is considerably more likely to get done. If the warning to evacuate is given and your employees' dependents are still in the high-risk areas, they will have little difficulty choosing between saving family and saving equipment. But, if they know that in such an event their plant has an emergency plan that considers the problem and prepares for it, this may help you retain the cooperation that will be needed for the hardening effort. Plans for protecting personnel are described in two of the booklets.

Not only manpower, but material and equipment resources must be committed to conduct the tasks required to complete plant hardening activities. Whether planning is done early or late, your response requires consideration of the same factors; hardening requires assessment of options, thoughtful decisions, and completion of task assignments on a schedule. If the planning is done early, much more will be accomplished. Planning should encompass the following factors:

- o Priorities for hardening equipment so that personnel, materials, equipment resources can be committed to produce the optimum result in the time available.

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

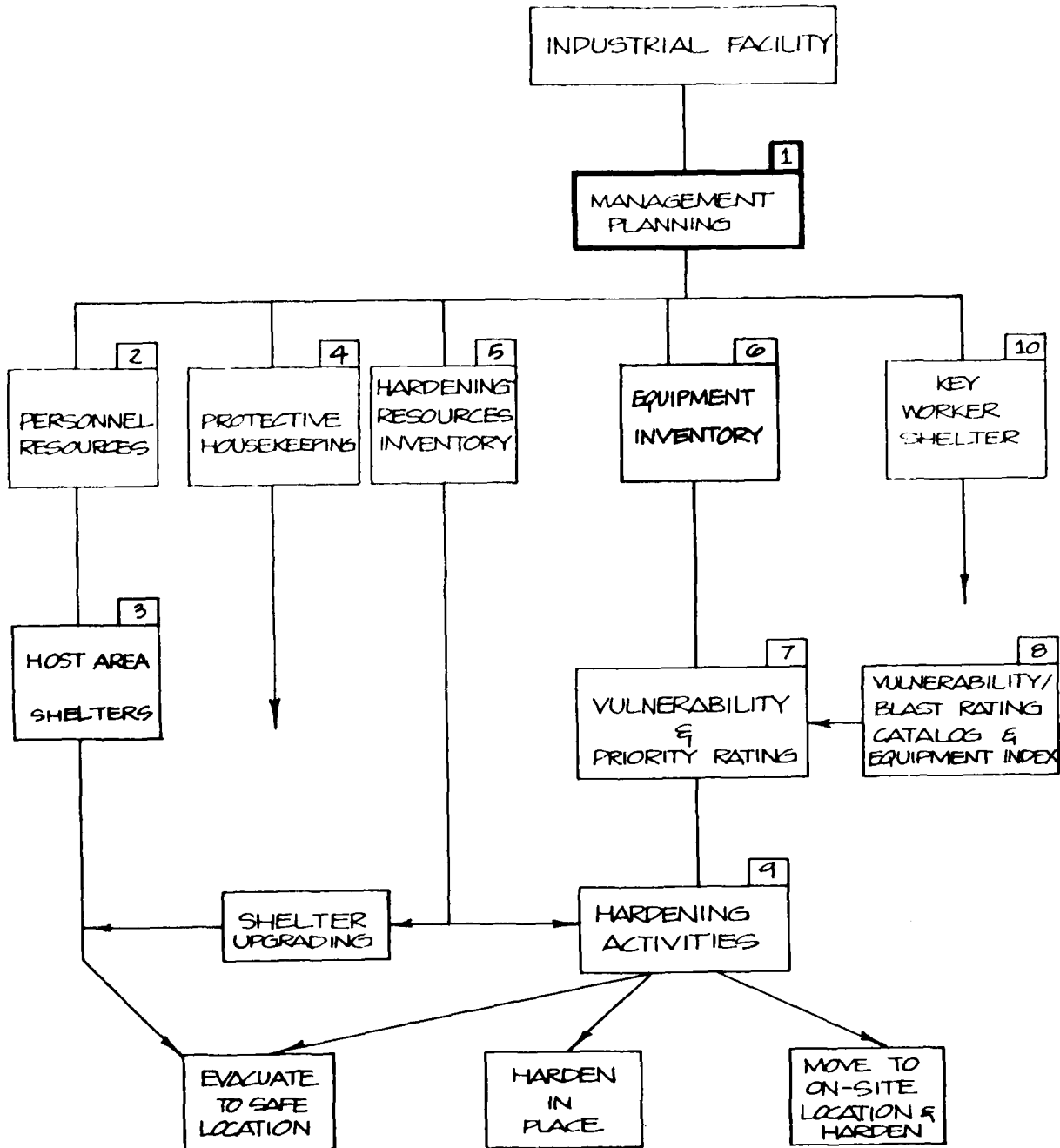


Fig. 4 Crisis Relocation Industrial Hardening Plan.

- o Consideration and establishment of a fallback position (i.e., less production, lower quality, or both) if necessary, to set workable priorities for hardening activities that can be completed:

What simpler, alternative production processes might be used, post-disaster, that would simplify hardening?

What items are absolutely essential (critical to production whatever the process)?

What are the relative importances of the remaining (less critical) items?

- o Options to reduce specific vulnerability of priority equipment:

Evacuate to host area

Move to safer location in plant and harden

Harden in place

- o Completion of inventory lists of priority equipment indicating those to be evacuated, those to be moved and hardened, those to be hardened in place, and those to be abandoned.

- o Decision as to specific actions to accomplish objectives, with resources allocated to task.

- o Options to reduce general plant vulnerability when evacuation of equipment is impossible or incomplete. These options involve — extensive plant cleanup to remove combustible materials, fragile equipment, loose objects; disconnection of electrical equipment from power lines; installation of standby power supplies in hardenable underground structures (with separate fuel supply also underground); neutralization of the risk from hazardous materials on site; etc. These options are described in the Plant Protective Housekeeping Booklet. Protective housekeeping appears to be the most cost effective measure

known to reduce vulnerability to equipment left onsite and to limit damage caused to neighboring plants. Current benefits are reduction in fire hazard, better plant safety records, safer hazardous materials storage, better preparation for power outages.

Booklets and worksheets that can assist management in organizing the planning, decision processes, and task assignments have been provided. Brief descriptions of each follow, so that assignments can be made. The last page of this booklet can be filled in to provide a record of the assignments.

PERSONNEL RESOURCES, Booklet 2. Maintain an effective industrial unit by developing employees and their dependents into an efficient survival team to improve security of plant personnel and equipment. Tasks here are:

- 1) To develop a roster of personnel that will be available.
- 2) To develop a procedure to help employees shut down households and arrange dependents' evacuation efficiently, rapidly, systematically, and compatibly with State and local plans (where they exist) to designated low-risk areas, with food and clothing supplies for a minimum of two weeks.
- 3) To develop a list of practical skills available among employees and dependents (e.g., nursing, paramedic, carpentry).
- 4) To develop a list of special provisions that must be prepared (for diabetics, handicapped, etc.).

HOST AREA SHELTERS, Booklet 3. Provides design and construction information necessary to establish shelters in the host area for use during the crisis period. Included are both quick-fix converted shelters, and expedient shelters where there is nothing to convert.

PLANT PROTECTIVE HOUSEKEEPING, Booklet 4. Develops an approach for implementing protective housekeeping that can reduce the severity of earthquake, hurricane, tornado, and weapons effect damage to equipment left onsite. Fires are the major destructive force in all such large disasters, so onsite combustible materials must be removed or neutralized. To reduce hazards from toxic and hazardous materials during recovery, containers must be protected from rupture or puncture. To reduce damage from electromagnetic pulses, all electrical systems not deliberately functioning must be unplugged from power lines, and antennas disconnected. To reduce puncture and other damage from missiles created by wind forces, loose materials, debris, containers, and vehicles must be relocated (tied down, evacuated, buried).

HARDENING RESOURCES INVENTORY Booklet, 5. Leads to a surveyed list of resources available to carry out the various plan elements that might be developed to harden the facility and to return it rapidly to production after the crisis is over. Hardening alternatives involve the movement of personnel, records, equipment to low-risk (non-target) areas; construction of revetments, berms, burial pits for equipment; lashing down packaged and cushioned equipment with cable, rope, chain link fencing and/or burying it; disassembly of vulnerable structures, etc. Returning the facility to production will require salvage tools, including winches, cranes, materials handling equipment, which may no longer be available (accessible), if left onsite. These resources are best evacuated to the host area so they will be in your hands when you are ready for them.

EQUIPMENT INVENTORY, Booklet 6. Leads to a list of plant equipment organized to establish hardening priorities. There may be a limit to the plant equipment that you will be able to protect with the time, materials, equipment, and personnel available. There are a number of approaches that can simplify this task. For example, suppose there is a great deal of redundancy in production equipment and processes at your plant. Redundancy provides the simplest means for establishing priorities: hardening activities can be planned around less

capacity and longer hours; e.g., consider a single shift production line including 4 punch presses, 6 drill presses, and 2 riveting machines (then evacuate or harden one combination of 2 punch presses, 3 drill presses, and 1 riveting machine and operate the other set with two shifts). If there is so little redundancy (or you already operate three shifts) that this option is not practical and there is not sufficient time, materials, or personnel to accomplish the hardening, then a plan may have to be established for alternative methods of production (requiring less equipment) so that you can salvage enough equipment to return to production without any serious bottlenecks. Should no simple concept (such as the two examples) present itself to guide your decision regarding hardening, then a quantitative method has been provided in Booklets 6 through 8.

VULNERABILITY/PRIORITY RATING & HARDENING DECISIONS, Booklet 7.

Provides approaches to setting priorities. The aim is a methodology to define, systematically, the relative importance to production of each item of equipment. Vulnerability and importance are combined in a single rating to provide the basis for ranking the order in which hardening activities can deliver the greatest overall reduction in plant vulnerability, based on your assignment of relative importance to operations and relative vulnerability of equipment in your plant. Plant personnel assigned to this task should have the ability to recognize alternative production methods that can be used in emergencies to maintain some production when there is damaged or inoperative equipment.

VULNERABILITY/BLAST RATINGS CATALOG & EQUIPMENT INDEX, Booklet 8.

Supplements to the Vulnerability/Priority Rating & Hardening Decisions booklet needed to accomplish tasks defined in Booklet 7.

HARDENING ALTERNATIVES, Booklet 9. A catalog of equipment hardening options. Categories available are:

- 1) Evacuate to a safe area;
- 2) Harden in place;
- 3) Relocate onsite to a safer location where hardening is simpler.

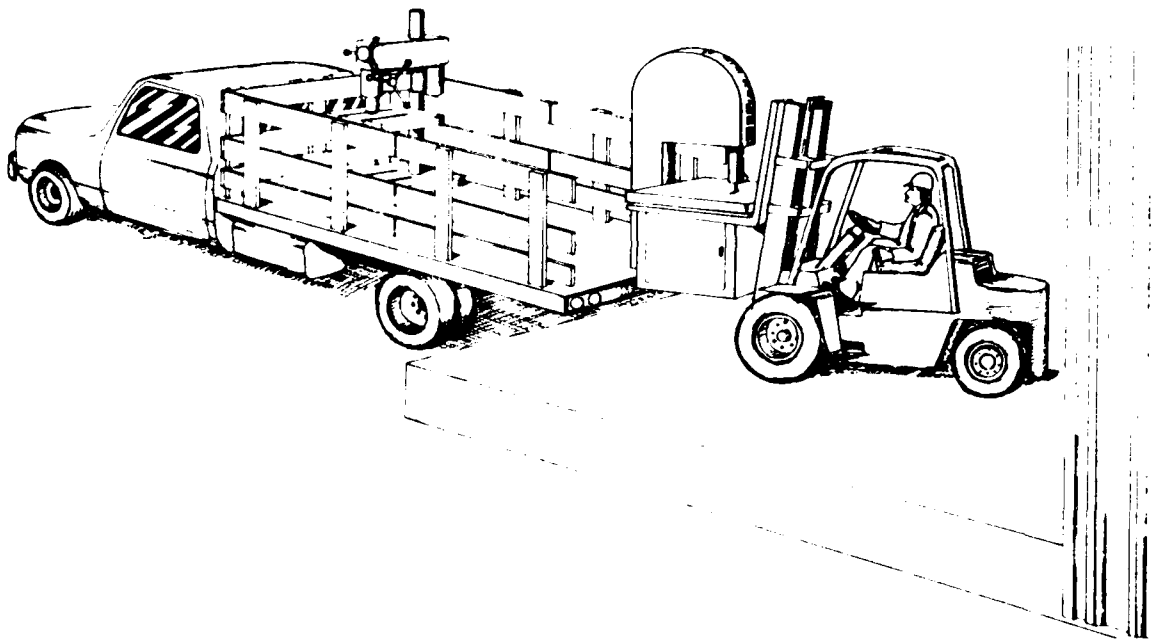
Sketches depicting ideas for hardening alternatives are furnished (see examples at the end of this booklet) to provide insight into the process.

KEY WORKER SHELTER, Booklet 10. Provides design and construction information necessary to establish shelters onsite at plants that will operate through the crisis with a skeleton crew.

A major post-attack problem at every plant will be the availability of utilities -- particularly electrical and gas utilities. Where plants are equipped with standby oil-fired systems and underground fuel tanks, they will be able to resume operations more rapidly in emergencies that damage utility power plants, particularly if special effort is taken to harden the standby systems. Those plants that generate their own electricity while producing process heat will be the least vulnerable, whatever the emergency, if they take advance precautions to harden their generating facility.

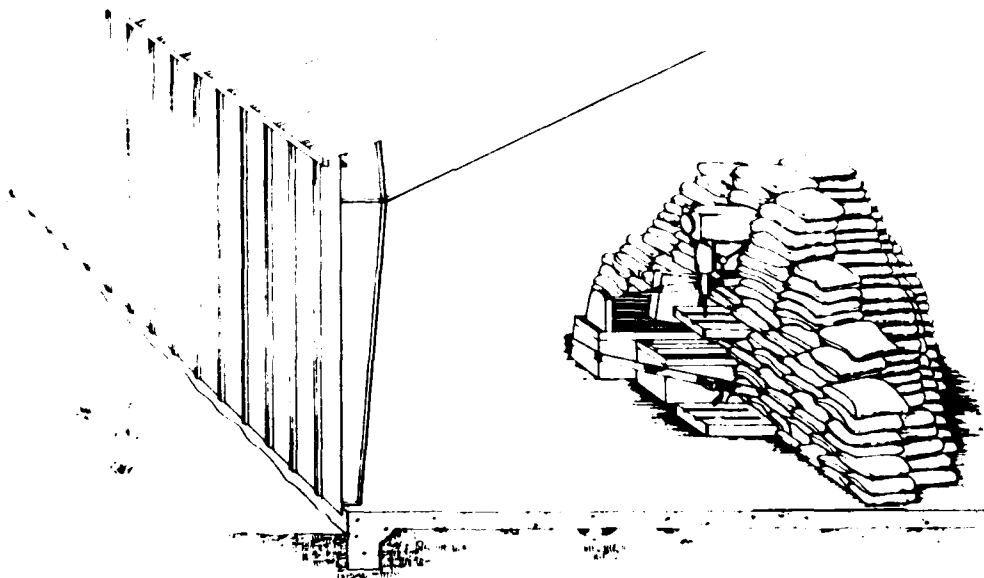
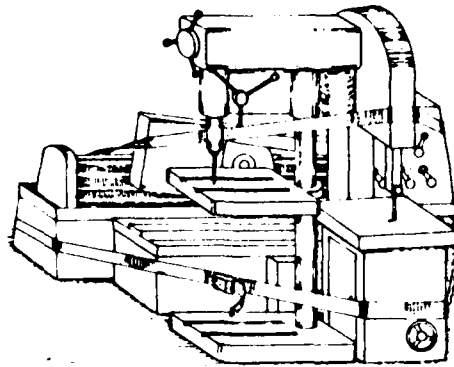
The following sketches identify general hardening techniques that can be applied to protect equipment.

TO SAVE YOUR EQUIPMENT



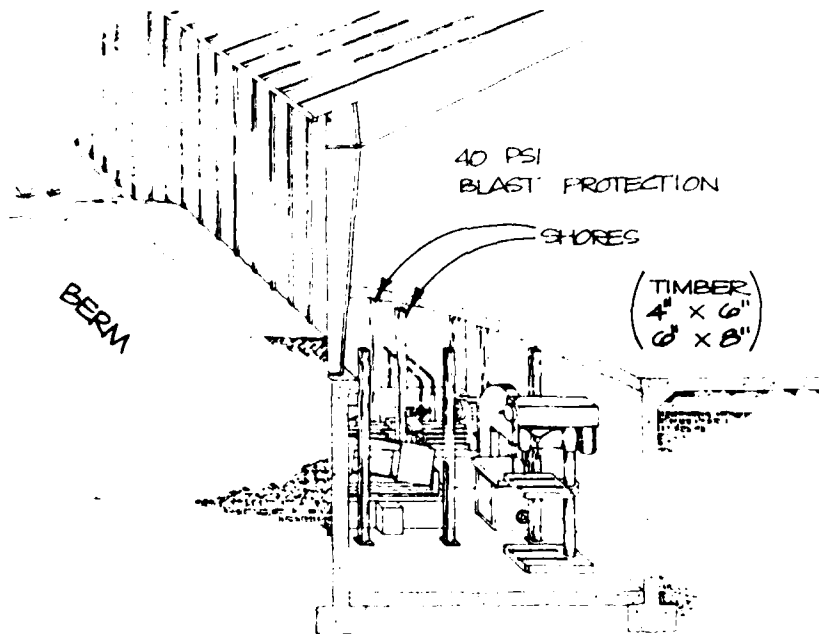
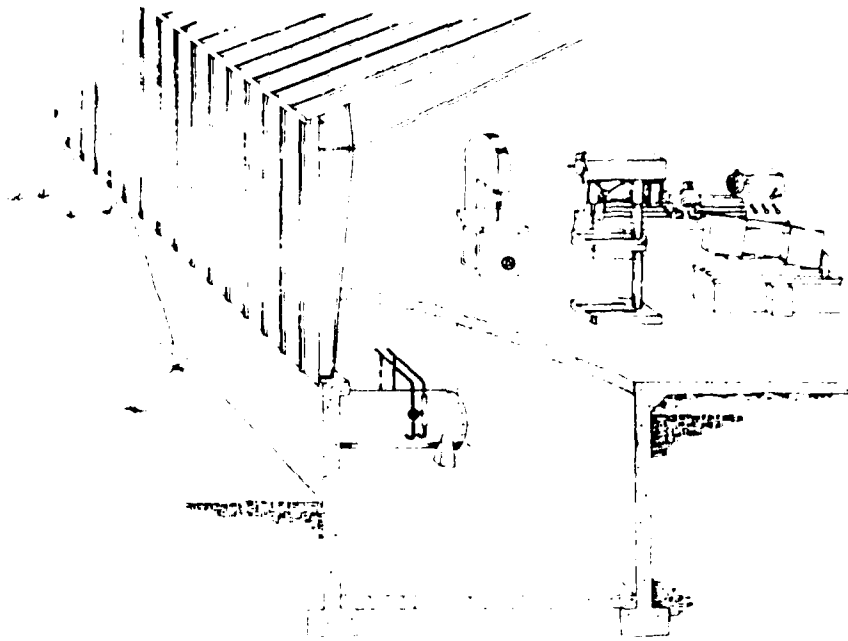
EVACUATE IT

TO SAVE YOUR EQUIPMENT

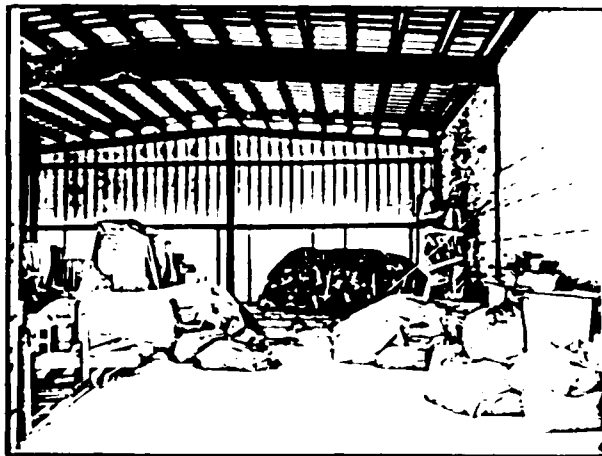


HARDEN IT IN PLACE

TO SAVE YOUR EQUIPMENT

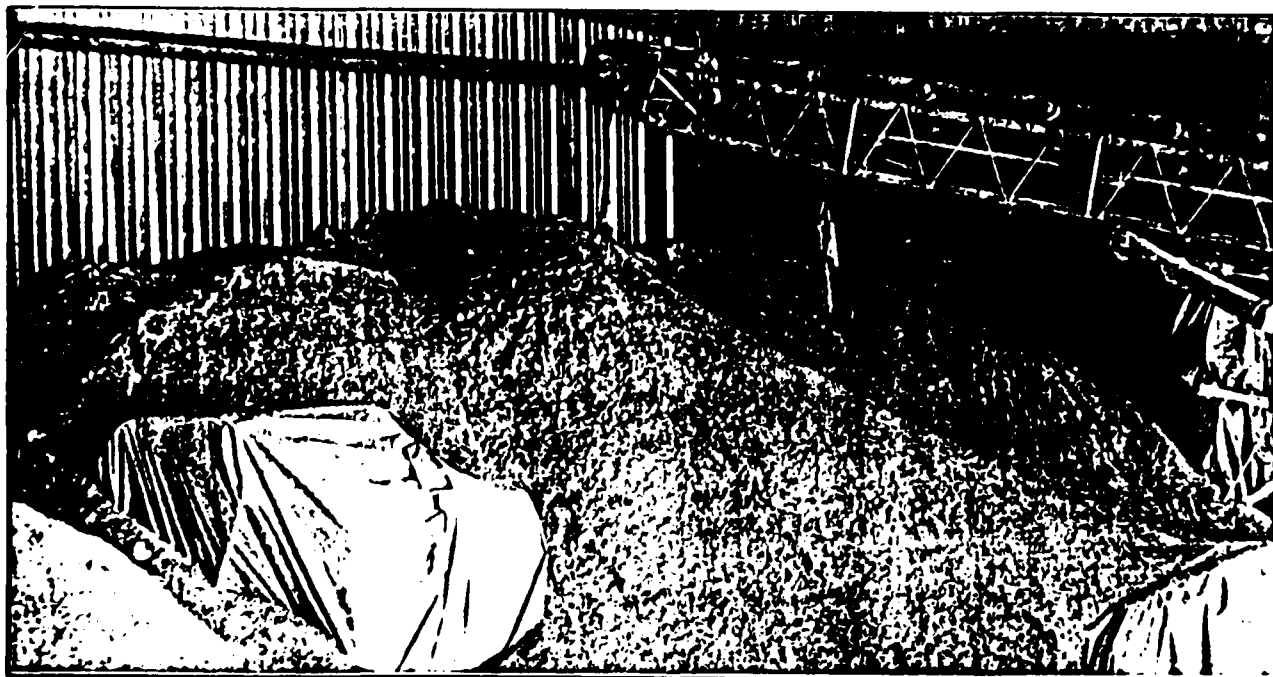


RELOCATE AND HARDEN IT



CRUSHABLE PACKING
HELD IN PLACE BY
PLASTIC SHEET FOR
BURIAL PROTECTION

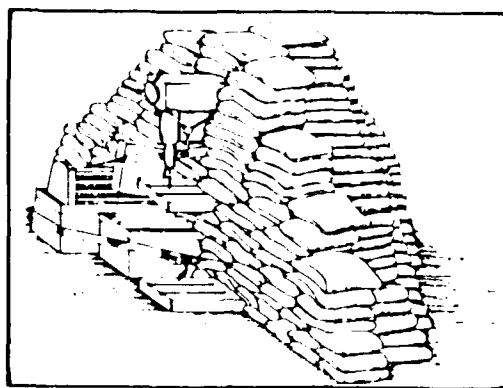
IF YOU CAN'T MOVE IT . . .



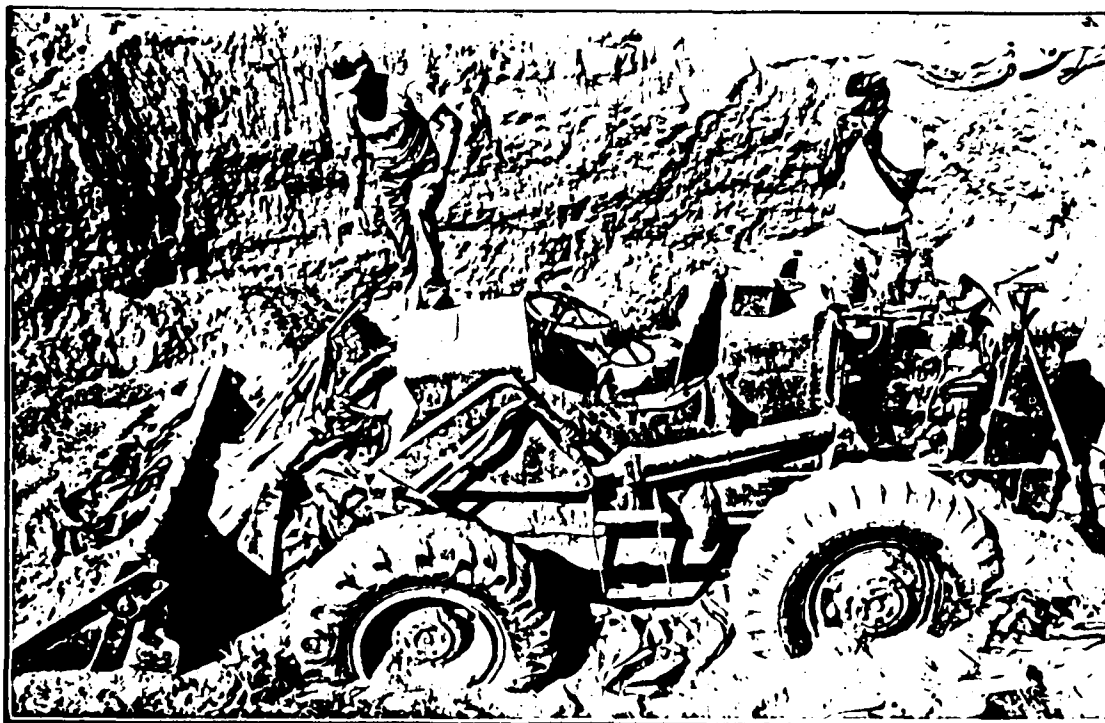
BURY IT IN-PLACE INDOORS .

IF YOU CAN MOVE THE EQUIPMENT BUT CAN'T HAUL IT AWAY

BURY IT OUTDOORS

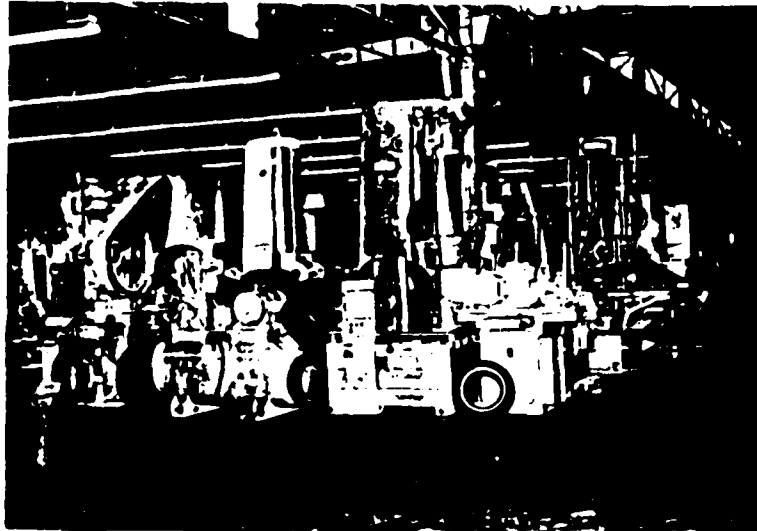


IN PAVED AREAS - SANDBAG IT

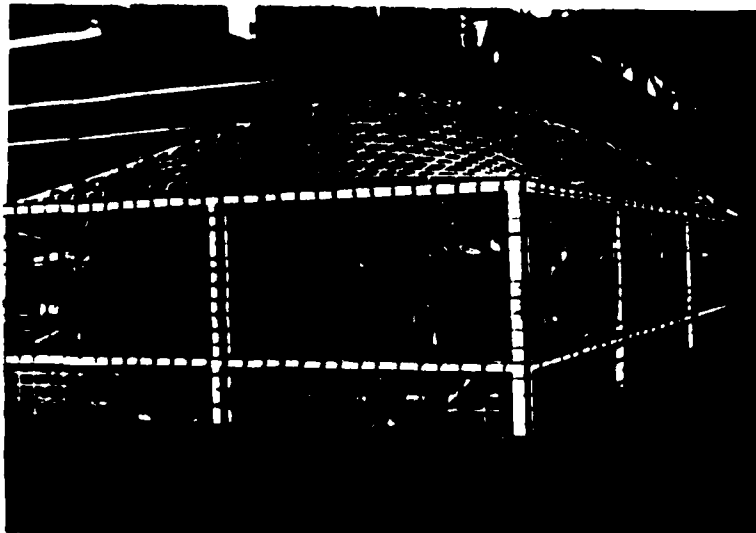


IN OPEN AREAS - PUT IT IN A TRENCH (COVER IT, IF THERE IS TIME)

IF YOU CAN'T BURY OR MOVE IT ...



CLUSTER MOVABLE EQUIPMENT AROUND IT.
WEDGE WOOD OR TIRE BUMPERS BETWEEN EQUIPMENT
TO PROTECT KNOBS, HANDLES, ETC.



WELD HEAVY I-BEAM CRIB AROUND IT; ADD
CHAIN LINK FENCE, STUFF WITH TIRES OR
LUMBER, AND COVER.

BLAST PROTECTION: 20 to 30 PSI

MANAGER'S PLANNING GUIDE

When you have decided whom to assign to carry out the tasks, fill in the blank spaces with appropriate names and distribute the booklets accordingly. Booklets 5 and 6 should be filled out by the Coordinator and returned to the Hardening Operations Manager. Should an evacuation warning be given, your coordinators should be ready to take action.

- STEP 1** Distribute Booklet 1, **Management Planning Guide**, to
Area Managers:_____
- STEP 2** Distribute Booklet 2, **Personnel Resources**, to:_____
 (coordinator)
- STEP 3** Distribute Booklet 3, **Host Area Shelters**, to:_____
 (coordinator)
- STEP 4** Distribute Booklet 4, **Protective Housekeeping**, to:_____
 (coordinator)
- STEP 5** Distribute Booklet 5, **Hardening Resources Inventory**, to:_____
 (coordinator)
- STEP 6** Distribute Booklet 6, **Equipment Inventory**, to:_____
 (coordinator)
- When Booklets 5 and 6 have been completed and returned to the manager, complete Steps 7 and 8.
- STEP 7** Distribute Booklets 7, 8A & 8B, and 9 to:_____
 (hardening operations manager)
- STEP 8** Distribute Booklet 10, **Key Worker Shelter**, to:_____
 (coordinator)

When Booklets 5 and 6 have been completed and returned to the manager, complete Steps 7 and 8.

- [illegible]

INDUSTRIAL PROTECTION GUIDE

**CRISIS RELOCATION
INDUSTRIAL HARDENING PLAN**

**PERSONNEL
RESOURCES**

EXERCISE 1

INDUSTRIAL HARDENING PLAN

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 2

PERSONNEL RESOURCES

This is one of ten booklets of the Industrial Hardening Manual
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SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

Booklet 2

PERSONNEL RESOURCES

Coordinator: _____
(name)

Alternate: _____
(name)

Objective: To develop plans for systematic relocation of employees and their dependents and to assess available skills.

This booklet is part of a plan to protect industrial plant equipment from possible damage in the event of a major disaster. It provides guidelines for developing an evacuation plan to move workers and their families to a safe area. Many impending disasters provide some kind of warning time, ranging from minutes to several days. With the longer warning times (e.g., hurricane, nuclear threat) it will be possible to evacuate populated areas.

Advance planning will allow you to:

- 1) Consult civil defense authorities, select your re-location site, and obtain pertinent printed matter.
- 2) Plan evacuation routes.
- 3) Coordinate transportation.
- 4) Define what everyone is to do and prepare alternatives in case of problems (defective vehicle, missing driver, etc.)
- 5) Provide a scheduled evacuation of personnel that will allow time to protect production equipment necessary to survival afterwards.

Your planning will make a difference. In a study conducted at a Boeing plant, 6,000 to 9,000 employees were able to complete a dry run exercise of the plant's industrial protection plan in three to four days.

INSTRUCTIONS FOR COORDINATOR

Develop and maintain a list of all employees' names, according to addresses and cities (or districts, in a large city).

Consult your local Civil Defense office for information on evacuation, and obtain pamphlets, maps, etc., that will be used for your evacuation plan. Provide the CD authority with the total number of employees and dependents that will need shelter so he can arrange an evacuation site.

Recruit and assign an area leader by city, district, or districts, so there are ten to twenty employees per leader grouped in moderate sized neighborhoods.

Instruct area leaders with the information gathered from the Civil Defense office.

Provide a list of employees in each assigned district to the appropriate leader, and the name of leader to employees in his district.

Notify area leader when an employee moves into or out of his district.

Set up communication links with leaders.

Notify leaders to hold group meetings to confirm plans.

Notify leaders when to put evacuation plans into effect.

Assign Area Leader to develop records of the following information for each employee in his district:

- 1) Number of dependents needing transportation.
- 2) Capacity of transportation available at each employee's home.
- 3) Special skills of dependents; e.g., nursing, construction, entertainment.
- 4) Number of personnel who are classed as dependents of employees in other industries.
- 5) Number and kinds of medical problems requiring special diets, medicines, etc. (for example, diabetes), by person.

Late Planners' Note: If you start to plan after the evacuation warning is given, you will need a place large enough to assemble all company personnel. If the company has more than several hundred employees, then it may be necessary to divide into groups of one to two hundred, organized by city or district of residence. Then subdivide into groups of ten to twenty, by neighborhood, with an area leader to carry out subsequent tasks.

INSTRUCTIONS FOR AREA LEADER

Use the records developed to organize and assign transportation -- assign drivers and use the largest capacity vehicles available.

Confirm assignments of riders and drivers so that all employees and families (plus supplies for two weeks of camping out) are assured of being evacuated. Establish a rendezvous point for all drivers in your group to ensure that everyone assigned in your district is accounted for before leaving for the safe area.

Prepare a backup plan in case of vehicle breakdown, and fix routes so missing members can be found quickly by tracing routes.

Notify members in your district of any assignment changes as they occur, or periodically.

Stress the importance of establishing and maintaining a schedule. Otherwise a late pick-up may take his own vehicle, create confusion, and add to traffic problems.

Distribute Civil Defense booklets including lists of what supplies to bring from home, how to shut down a household when an evacuation order is given by authorities, and what routes to take to get to the assigned safe area.

Conduct group meetings when the coordinator requires, to confirm assignments and understanding of members.

Take charge of operations in your neighborhood on evacuation day.

Run an extra vehicle to provide for alternatives such as:

- o Pick up nursery school children
- o Pack extra food and gear
- o Replace a vehicle if it breaks down and must be abandoned.

The following pages are excerpts from a Civil Defense manual, which should be available for distribution to your employees, either from your local Civil Defense authority or in-house.

WHAT YOU SHOULD EVACUATE

The local areas around your company and your home could be potential targets if the United States is attacked. Areas where the greatest danger may exist are shown on the map. To protect the people living in these areas, plans have been made to relocate them to nearby areas which are considered to be safer from direct attack.

Those living in risk areas who do not leave according to instructions will be subject to strictly enforced curfews. Movement within the risk areas will be severely restricted to protect the property of those who have evacuated. In addition, most facilities or services cannot be provided in risk areas during the evacuation period. In general, food and retail outlets will be closed. Available food and goods will be used to supply the evacuated population in the reception areas.

If an attack occurs, the best existing public shelters within the risk areas will be reserved for key workers who will be working in essential industries, and for hospitalized or institutionalized people who cannot be evacuated. Water, electricity, and gas service may be shut off. You may become isolated in a risk area.

WHAT YOU WILL DO

When official notification is given, all those living in the risk area shown on the map will be directed to evacuate to reception areas in nearby counties; that is, from a place of possible danger to a place of greater safety.

You can determine whether you should evacuate by locating where you live on the map. If it is within a risk area, you should be prepared to leave if notification is given. Two days, or possibly more, may be available to complete the evacuation. However, you should prepare now.

WHAT TO DO BEFORE YOU LEAVE

If you have chosen to relocate with your company, determine what route you are to take and listen to your transistor radio to hear if traffic is moving on it, or if an alternate route is designated. Re-unite with all family members who would normally travel with you, including nursing home residents, etc. Unless you are directed otherwise (see following box) this may delay your departure.

Make certain your vehicle contains as many of the items on page 3 as possible, or the items specified, if you are to be picked up. Make sure your vehicle is filled with fuel and normal emergency road equipment. Emergency gas stations are listed on page . Turn all utilities in your home off at the main — water, gas, electricity. Stay tuned to a station providing updated information in your area. Depart as close to the time suggested as you can.

IF YOU HAVE A FAMILY MEMBER IN A HOSPITAL, NURSING HOME, ETC.

Collect ambulatory patients not requiring close medical attention. Most hospital patients will be evacuated. However, if it is impossible for one to be moved because of special care requirements, that person will be cared for during the evacuation period. Similar consideration will be given to those residing in other institutions. Shelter and care will be provided in case of an imminent attack.

WHAT TO DO WHEN YOU ARRIVE

When you reach a major community or town in your assigned reception county, proceed immediately to your assigned reception area.

At the center, you will register yourself and your family. Reception county officials will make every effort to assign you to a place to sleep, in a larger building or possibly with a private household that has volunteered to share their home.

Lodging in Public Buildings...

If you are assigned to a public building such as a school, church, or other temporary lodging center, do everything you can to help maintain order and sanitary living conditions. Elect a leader and form working groups to help local officials and volunteers with such tasks as:

- o Cooking and feeding services
- o Providing water supply
- o Cleaning up trash and garbage
- o Maintaining order
- o Assuring quiet during sleeping hours
- o Organizing recreation and religious activities
- o Arranging medical care for the sick and assisting the handicapped.

Excerpted from "Preparing Crisis Relocation Planning Emergency Public Information," Working Draft CPG-2-8-F, February 1977.

HOW TO KEEP INFORMED

Listen to the radio for information and advice from National, State, and local officials. You will be told when you should return home. **DO NOT RETURN HOME BEFORE YOU ARE ADVISED TO DO SO.** It is impossible to predict how long you will have to stay in the reception area. It could be only for a few days or could last for a week or more.

If a nuclear attack should occur and the Emergency Broadcasting System (EBS) is in operation, a number of radio broadcast stations will remain on the air to provide emergency information. All other radio stations will stop broadcasting. Those emergency stations remaining on the air will provide you with information and instructions that you will need.

WHAT TO TAKE

You should prepare to take those things you would take for a vacation trip of a week or more - plus other items on the checklist on page 3. Do not take all your favorite belongings. Your home and property will be protected from looters while you are away.

The checklist on page 3 includes items you will need for your stay in the reception area. It also includes tools needed to construct a fallout shelter and those things you will need to take into the shelter if an attack occurs.

All items on this list should be included if you are going to use your own car for transportation. If you do not have a car and will be using company transportation, take only those items which have been marked on the list given on page 3.

PETS

No arrangements have been made to house pets in the reception area. Therefore, if you take your pet with you, it will probably be confined to your car and you will be responsible for its care. If you elect to leave your pets behind, be sure they are confined in a sheltered area with an adequate supply of food and water. Above all, do not turn your pet loose to fend for itself while you are gone.

HOW TO GET THERE

If you have a car, truck, camper, or recreation vehicle, drive to your designated reception area, using the route planned. Remember that several days should be available for relocating all those living in the risk area. Take the time you need to prepare and pack.

Evacuation routes have been designated to assure residents will be equally distributed among the reception counties so that there will be adequate food and lodging for you and your family. If you use a route not assigned to you, you may find the reception area you have chosen is filled, and there is no room or accommodations for you. Follow the evacuation route to the reception county as indicated. Wherever possible, police officers will be on duty to advise and direct you. Obey all instructions by law enforcement officers.

If you get caught in a traffic jam, turn off your engine, remain in your car, listen for official instructions (but not on your car radio), and be patient. Do not get out of line to find an alternate route. All routes will be crowded. If traffic is stopped for an hour or more, do not leave your car for any reason.

Be sure you have adequate gasoline when you start out. **DO NOT BUY ANY MORE GAS THAN YOU WILL NEED.** Gasoline will be in short supply and will be needed to provide you with food and other essential supplies. But if you run out of gas or have other mechanical difficulties, move your car to the side of the road out of the traffic lanes to allow traffic to continue. Service to stalled autos will be available during the evacuation period. Leave your hood up as a sign that you are stalled, and you will be assisted as soon as possible.

PREPARE !

Here are some things you can do that will better prepare you and your family to survive and recover if a nuclear attack should occur.

- o Go over the checklist of things to take with you. If you will need prescription medicines or special food, check to see if you have an ample supply.
- o Collect all of your valuable papers and put them in one place, preferably wrapped in plastic in a metal container (tool box, fishing tackle box).
- o Check your home for security. See that all locks are secure. Store valuables in a safe place. Shut off utilities if you evacuate or if attack is likely.

o Close all window blinds, shades, and draperies. This can help prevent fires from the heat wave of a nuclear explosion.

o If you will use your car, be sure you have enough gasoline.

o Be sure to take tools — especially SHOVELS, PICKS, HAMMERS. These will be essential in improvising fallout shelters. Also take work gloves.

o Stay tuned to your local TV or radio station for instructions. They will broadcast the notice to evacuate, if directed by government officials.

Read this supplement carefully and discuss it with you family. If you have special problems not discussed in these instructions —

CALL _____

SURVIVAL SUPPLIES . . . FROM YOUR HOME . . . FOR YOUR FAMILY

CLOTHING AND BEDDING

- ☐ work gloves
- ☐ work clothes
- ☐ extra underclothing
- ☐ outer wear (depending on season)
- ☐ rain garment
- ☐ extra pair of shoes
- ☐ extra socks or stockings
- ☐ blankets and sheets
- ☐ 1 sleeping bag per person, plus
- ☐ 1 suitcase per person

FOOD AND UTENSILS

- ☐ take all the food you can carry (particularly dried or canned food requiring little preparation)
- ☐ water
- ☐ thermos jug or plastic bottles
- ☐ bottle and can opener
- ☐ eating utensils
- ☐ plastic or paper plates, cups, and napkins
- ☐ candles and matches
- ☐ plastic drop cloth

PERSONAL, SAFETY, SANITATION, AND MEDICAL SUPPLIES

- ☐ battery operated (transistor) radios, extra batteries
- ☐ flashlight, extra batteries
- ☐ soap
- ☐ toothbrush & toothpaste
- ☐ shaving articles
- ☐ sanitary napkins
- ☐ detergent
- ☐ towels and washcloths
- ☐ toilet paper
- ☐ emergency toilet
- ☐ garbage can
- ☐ newspapers
- ☐ first aid kit
- ☐ special medication (insulin, heart tablets, or other)

BABY SUPPLIES

- ☐ diapers
- ☐ bottles and nipples
- ☐ milk or formula
- ☐ powder
- ☐ rubber sheeting, etc.
- ☐ 1 suitcase

TOOLS FOR CONSTRUCTING A FALLOUT SHELTER

- ☐ pickax
- ☐ shovel
- ☐ saw
- ☐ hammer
- ☐ broom
- ☐ ax
- ☐ crowbar
- ☐ nails and screws
- ☐ screw driver
- ☐ wrench

IMPORTANT PAPERS

- ☐ Social Security card
- ☐ deeds
- ☐ insurance policies
- ☐ stocks and bonds
- ☐ will
- ☐ savings account books
- ☐ credit cards, checks, and currency
- ☐ lockbox

DO NOT TAKE

- ☐ FIREARMS —(Guns of any kind)
- ☐ NARCOTICS
- ☐ ALCOHOLIC BEVERAGES

Excerpted from "Preparing Crisis Relocation Planning Emergency Public Information," Working Draft CPG-2-8-F, February 1977.

SAMPLE MEAL PLANS: *No Cooking Facilities*

First day	Second day	Third day
MORNING		
Citrus fruit juice. ¹ Ready-to-eat cereal. Milk, cold coffee, ² or tea. ² Crackers. Peanut butter or other spread.	Fruit juice. ¹ Canned beef hash. ¹ Crackers. Spread. Milk, cold coffee, ² or tea. ²	Orange fruit segments. ¹ Ready-to-eat cereal. Peanut butter. ¹ Milk, cold coffee, ² or tea. ²
NOON		
Spaghetti with meat sauce. ¹ Green beans. ¹ Crackers. Spread. Milk, cold coffee, ² or tea. ²	Baked beans. ¹ Brown bread. ¹ Tomatoes. ¹ Fruit. ¹ Milk, cold coffee, ² or tea. ²	Chile con carne with beans. ¹ Crackers. Fruit. ¹ Cookies. Milk, cold coffee, ² or tea. ²
BETWEEN MEALS		
Fruit-flavored drink or fruit drink.	Milk.	Tomato juice.
NIGHT		
Lunch meat. ¹ Sweet potatoes. ¹ Applesauce. ¹ Milk, cold coffee, ² or tea. ² Candy.	Pork and gravy. ¹ Corn. ¹ Potatoes. ¹ Instant pudding. Fruit juice. ¹	Sliced beef. ¹ Macaroni and cheese. ¹ Peas and carrots. ¹ Crackers. Milk, cold coffee, ² or tea. ²

¹ Canned. ² Instant.

SAMPLE MEAL PLANS: *Limited Cooking Facilities*

First day	Second day	Third day
MORNING		
Citrus fruit juice. ¹ Ready-to-eat cereal. Milk. Hot coffee, ² tea, ² or cocoa. ²	Citrus fruit juice. ¹ Hot cereal (quick-cooking). Milk. Hot coffee, ² tea, ² or cocoa. ²	Prunes. ¹ Ready-to-eat cereal. Milk. Crackers. Cheese. Hot coffee, ² tea, ² or cocoa. ²
NOON		
Vegetable soup. ¹ Potato salad. ¹ Crackers. Ham spread. ¹ Milk. Candy bar.	Beef-and-vegetable stew. ¹ Green beans. ¹ Crackers. Peanut butter. Milk.	Chile con carne with beans. ¹ Tomatoes. ¹ Crackers. Hot coffee, ² tea, ² or cocoa. ²
BETWEEN MEALS		
Fruit-flavored drink or fruit drink.	Tomato juice. ¹	Fruit-flavored drink or fruit drink.
NIGHT		
Beef and gravy. ¹ Noodles. ¹ Peas and carrots. ¹ Instant pudding. Hot coffee, ² tea, ² or cocoa. ²	Tuna fish, ¹ cream of celery soup, ¹ mixed sweet pickles ¹ —combined in one dish. Fruit. ¹ Cookies. Hot coffee, ² tea, ² or cocoa. ²	Lunch meat. ¹ Hominy. ¹ Applesauce. ¹ Cookies. Peanuts. Hot coffee, ² tea, ² or cocoa. ²

¹ Canned. ² Instant.

Excerpted from "Preparing Civil Defense Planning Emergency Public Information," Working Draft, D-2-8-F, February 1977.

INDUSTRIAL

PROTECTION

GUIDE

**CRISIS RELOCATION
INDUSTRIAL HARDENING PLAN**

***HOST
AREA
SHELTERS***
BOOKLET 3

SCIENTIFIC SERVICE, INC.

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 3

HOST AREA SHELTERS

This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

Booklet 3
HOST AREA SHELTERS

Coordinator: _____
(name)

Alternate: _____
(name)

Objective: To provide direction for establishing shelter space in the host area for employees and their families to relocate to in an emergency.

This booklet is part of a plan to protect industrial plant equipment from possible damage in the event of a major disaster. It provides design and construction information necessary to establish shelters in the host area (see Glossary, page 45) for use during the crisis period. Included are both quick-fix converted shelters, and expedient shelters where there is nothing to convert.

By organizing this primary survival task, there is a greater chance that other tasks to enhance plant survival will be carried out also -- and survival as an organized group of families is easier and more likely than families alone.

TASK SUMMARY

1. Determine number of employees and family members evacuating.
2. Define shelter and space requirements needed to accommodate shelterees.
3. Establish shelter stocking requirements.
4. Establish host area liaison, obtain and survey assigned space, assess upgrading requirements.
5. Estimate materials, equipment, labor, and time required to prepare shelter space.
6. Complete logistics preparation and upgrading sequence so you will be prepared to implement beginning on warning day.

Task 1: Determine the Number of Shelterees

Obtain the following information from the coordinator of Booklet 2:

1. Number of persons to be sheltered (employees plus dependents)
 - (A) Age
 - (B) Special skills
2. Numbers of persons with special physical, medical, or dietary needs.

Use this information to figure shelter space and stocking requirements and to submit to your local Civil Defense Office with your request for a Host Area assignment. Refer to the Task 1 checklist, page 5.

Task 2: Shelter Space Requirements

Using Task 1 information, plan enough shelter space and supplies for everybody to survive two weeks without need to leave the shelter. You will need at least 10 square feet of floor space and 65 cubic feet of air volume per person, plus storage space for supplies. (Refer to the Task 2 checklist, page 5.)

What else to look for:

- o Shelters must support the equivalent of two feet of earth cover.
- o Shelters should be located so that collapsing buildings, trees, junk, or debris will not prevent escape of sheltered personnel.
- o Two exits should be provided, located as far apart as practicable. Because debris may block one exit, an alternative escape exit should be available.
- o Below ground shelters, unless water-tight, should not be located in areas with high ground water or subject to flooding from surface runoff, ruptured tanks, or broken pipelines.

- o Shelters should **not** be located near hazardous or flammable materials.
- o Existing basement areas that are potentially available for upgrading and existing underground facilities must be capable of being cleaned and made habitable in 72 hours. The extent of cleaning necessary will depend on shelter option selected.

Equipment Needed:

A fully equipped shelter should contain the following:

- o A complete life support system adequate for a minimum of two weeks stay-time. A detailed list is included in the Task 3 section.
- o Ventilation equipment adequate to supply at least 3 cubic feet per minute per person. (Larger air volumes to 40 cfm, or an air-drying system, may be required in the hot or humid areas of the country.) Hand-cranked systems are desirable, as power may be unavailable.
- o Emergency power system.
- o Radiation monitoring equipment.
- o Communication equipment, battery-powered with rechargeable cells.
- o Battery charger or spare batteries.
- o Sleeping facilities.
- o Firefighting equipment.
- o Tools and equipment stored inside to aid in exiting the shelter, to remove debris and roadblocks during evacuation, and for rescue of people from other shelters as necessary.

HOST AREA SHELTERS - SPACE REQUIREMENTS

TASK I & II CHECKLIST

Number of Shelterees (_____)
Company Name

- 1) Number of Men _____
- 2) Number of Women _____
- 3) Number of Children _____
- 4) Number of Handicapped _____

Sheltered Total Number _____

TASK II

Shelter Space Requirements

- 1) Floor Space $10 \times$ Sheltered Total Number = _____ S.F.
- 2) Allowance for Shelter Stocking and Equipment
Storage (from Task III Checklist) = _____ S.F.
- Total _____ S.F.
- 3) Air Volume $65 \times$ Sheltered Total Number = _____ C.F.
- 4) Ventilation = 3 cubic feet per minute per
person.
3 x Sheltered Total Number _____ CFM*

* Provide for additional capacity in humid areas, up to 40 CFM per person.

Provide copies of this form as follows:

- 1 to local Civil Defense Office with request for Host Area space.
- 1 to Host Area Civil Defense official when contacted.
- 1 to owner of shelter space.

Task 3: Establish Shelter Stocking Requirements

Shelter Stocking: Early planning for provision of food, medical and other supplies must be made, since warning of an impending disaster may not leave sufficient time for last minute preparation (not to mention purchases). Each Host Area shelter should be provided with a minimum of two weeks supply of food and water for each shelteree. Note that although shelterees are instructed to bring supplies when they evacuate, not all of them will. Those supplies brought will provide additional backup for Host Area emergencies.

Water Supply: An adequate water supply is very important to survival. A healthy individual can survive for four weeks without food, but will not survive more than a few days without water or similar fluids. The minimum water each individual should be provided for survival is one gallon per day -- one-half gallon for drinking and one-half gallon for other purposes. The water must be accessible from inside the shelter. It can be stored in containers in the shelter or connected to an external storage source independent of municipal supply systems. A supply of 17 gallons per person is a good estimate, and includes a 20% contingency.

Food Supply: To provide a food stockpile, three factors are important: (1) nourishment (food value in relation to volume); (2) long shelf life; and (3) ease of preparation. Of less importance are palatability and cost. Balanced diets are not necessary, since the food is intended for only a limited survival period.

Select foods that require little storage space, that keep for months without refrigeration, and that can be eaten uncooked, if necessary. Canned foods will stay in good condition for six or more months if kept in a dry, cool, dark place (preferably not above 70°F, or below freezing). Replace canned foods at least once a year and uncanned packaged foods at least every three months. Food purchased for shelter use should be provided in container sizes that minimize waste. This should be simple to manage at meal time.

Diabetics, or persons with food tolerance or food allergy problems, may require special diets and/or medication. Special requirements should be

established, and provisions made: Stocking, refrigeration, and assignment where these supplies and attention can be provided. A sick shelteree will become a management and morale problem.

Table 1 is a list of foods suitable for shelter use to supply one adult a minimum of 2,000 calories per day.

Special Shelter Stay Considerations: Some special shelter stocking items and considerations are important to the safety and welfare of shelterees. These items are listed in Table 2.

Radio: An operating battery-powered radio is essential to shelter life, morale, and recovery. Since radio reception is cut down by radiation protection, a radio reception check must be made as soon as the shelter is completed. An outside antenna will be necessary to receive CONELRAD broadcasts, which have weaker signals than normal broadcasts.

Fire Extinguisher: An operating fire extinguisher should be accessible in each shelter. The close quarter environment would result in disaster if even a small fire started. It should be selected to be safe to use in an enclosed space.

Waste Disposal: Long-term storing of garbage and human wastes inside the shelter may create a health hazard. Within three or four days it should be safe to make short forays outside, so wastes should be buried at a previously selected location near the shelter -- a minimum of 12 inches in the earth is required. If the disposal area is excavated prior to the time shelterees enter the shelter, exposure time for people performing waste disposal will be minimized. Canvas boots or plastic bags should be worn on shoes when leaving the shelter and removed when entering. Disinfectants and deodorizers should be stored in the shelter to treat wastes until disposal.

Checklist: A stocking requirements checklist is provided on page 11. You will need to complete it so that checklists I and II may be completed.

TABLE 1. REQUIRED FOOD SUPPLIES PER PERSON FOR HOST AREA SHELTERS
(Long Stay-Time up to 2 weeks)

Food Item	Total Weight*	Daily Amount
<u>Water</u> - Stored in a dark place in clean containers with tight fitting lids. Rinse and refill containers every 3 months. 14 gals		4 qts
<u>Milk</u> - Nonfat, dry	20 oz	1/3 cup
Evaporated	14 oz	1 oz
<u>Juices</u> - Tomato, grape, apple. In crown capped bottles only. Store upright.	64 oz	1/2 cup
<u>Fruits</u> - Applesauce, pears, peaches. In glass jars, glass lids only. Store upright.	112 oz	1 cup
<u>Vegetables</u> - Corn, peas, beans, spinach	112 oz	1 cup
<u>Soups</u> - Canned or dehydrated (in can).	112 oz	1 cup
<u>One-Dish Meals</u> - Canned goods including chicken and rice or noodles, pork and beans, baked kidney beans, chile con carne, and beef stew.	208 oz	2 cups
<u>Spreads</u> - Jam, jelly, marmalade	14 oz	1 tbs
Peanut butter	14 oz	1 tbs
<u>Crackers</u> - in glass or cans.	56 oz	25 - 30
<u>Beverages</u> - Instant coffee, tea or cocoa	4 oz	3 tsp
<u>Sugar</u>	4 oz	3 tsp
<u>Hard Candies</u>	16 oz	1 oz
<u>Salt</u>	4 oz	1/4 oz
<u>Sterno</u>	4 cans	1/4 can

* To provide a sufficient amount, add 20% to the above quantities

TABLE 2. HOST AREA ESSENTIAL SUPPLIES
(Long Stay-Time up to 2 weeks)

Cooking & Serving Equipment

Cooking unit
Cups
Napkins or paper towels
Bottle opener
Plates
Matches
Can opener (2)
Double boiler
Eating utensils
Measuring cup
Pocket knife
Large boiling (5 or 10 gal) kettle

Clothing & Bedding

Towels and wash cloths
Sleeping bags or blankets & sheets
Spare clothing

Sanitation Supplies

Soap
Toilet tissue & sanitary napkins
Disinfectant (chlorine, bleach)
Insecticide
Garbage can
Human waste can
Emergency toilet
Plastic bags with ties (18 per person)
First aid kit (large)

Tools & Miscellaneous Items

Candles
Hammer
Wrench
Bucket
Shovel
Pliers
Screwdriver
Brooms (small)
Batteries
Flashlight
Calendar
Clock or watch
Axe
Crowbar

Emergency Generator, fuel and oil with necessary cords, plugs, lights

TABLE 2. HOST AREA ESSENTIAL SUPPLIES (contd)
(Long Stay-Time up to 2 Weeks)

Radio (battery operated with spares)

Battery Charger for radio batteries

Radiological monitoring equipment

Evacuation Supplies

Gasoline

Tent

50-mile map of area

Recreational & Spiritual Supplies

Bible

Books

Games

Song books

HOST AREA SHELTERS - STOCKING REQUIREMENTS

TASK III CHECKLIST

Shelter Stocking Requirements (2 Week Stay-Time)

- 1) Total the space required in the shelter(s) for water, food, and supplies, including additional space for supplies brought by evacuees (shelterees). These supplies should be accessible without leaving the shelter.
Equivalent Floor Space _____ S.F.
 - 2) Identify special foods, supplies, or special dietary needs for shelterees that require them. Provide a 3-week supply for such persons and make necessary designations on supplies to indicate their shelter destination and proposed use.
Equivalent Floor Space _____ S.F.
 - 3) Provide a radio for each shelter, and test it inside shelter for performance under shelter conditions — provide extra batteries.
Equivalent Floor Space _____ S.F.
 - 4) Provide sealed cans for food and human waste.
Equivalent Floor Space _____ S.F.
 - 5) Provide radiation detector in each shelter.
Equivalent Floor Space _____ S.F.
 - 6) Provide fire extinguishers.
Equivalent Floor Space _____ S.F.
- Total Floor Space Allowance: * _____ S.F.

* Total to be entered on Line 2, Task II Checklist, page 5.

Task 4: Host Area Liaison, Assignment and Assessment of Shelter Space

- o Provide a copy of the completed Task I and Task II checklists to your local Civil Defense office so that the information can be used to coordinate allocation of Host Area shelter spaces. Your local Civil Defense office will provide you with the name of the Host Area Civil Defense contact for your company. If no information is available, try the State Office of Emergency Services -- or go to the alternatives in Appendix A, if time is short.
- o When you obtain the name of the Host Area contact, send a representative to confirm the number of evacuees needing shelter (Task 1 checklist). Have him identify the assigned shelter space, and make a preliminary site reconnaissance of the space using Task 4 checklists 1 and 2. The remainder of this Task 4 section indicates how to do this.
- o Your representative should meet with the shelter space owner as well as the Host Area Civil Defense people to review your shelter assessment form. Lack of Host Area response in converting the assigned building space into an effective shelter, or any other incompatibilities in timing, upgrading, resources, or interfaces identified on the form may require the use of alternative space delineated in Appendix A. The possibility of interface problems should be discussed before your representative meets with the Host Area people. The goal of his assignment is to determine the specific course of action that is best so that resources can be allocated and unnecessary problems avoided.
- o At the Host Area meeting, your representative should arrange for and provide secure storage space for all upgrading resources and stocking supplies. Storage should be as near the shelter area as possible.

HOST AREA SHELTERS - SHELTER IDENTIFICATION

TASK IV CHECKLIST 1

Owner and Site Identification

(Use one sheet for each assigned building)

Assigned Facility I.D. _____ Date _____

Owner's Name _____ Owner's phone No. _____

Owner's Address _____

Building Name _____

Street Address _____

City _____ State _____ Zip _____ X-Street _____

No. Stories _____ No. of Basement Levels _____

Use _____ Special Facilities _____

General Facility Data

Yr. Built _____ Building Pop. _____ Air Source Natural _____ Mech. _____

Water Storage _____ gals. Water Source _____ Heating _____ Aux. Power _____

General Public Access Commodes _____

Shelter Space Reconnaissance and Review

	<u>Yes</u>	<u>No</u>
a) Will owner make space accessible?	_____	_____
b) Is space to be used now empty?	_____	_____
c) Is stored material relocatable now?	_____	_____
d) Will owner relocate it (or will you have to)?	_____	_____
e) Floor Type	Ceiling Type (pull out dropped ceiling section to determine)	
Wood _____	_____	_____
Concrete _____	_____	_____
Steel _____	_____	_____

HOST AREA SHELTERS - UPGRADING

TASK IV CHECKLIST 2

Basement Shelter Option

- 1) Available basement area? _____ Is it upgradable? _____

If not, locate expedient shelter option. (see Expedient shelter checklist, Appendix A)

- 2) Space upgrading Length _____ Width _____ Height _____

a) Type of upgrading Studwall _____

Post & Beam _____

- b) Number of exits, windows and other passages for closures required?
(All openings must be closed off so that radiation levels in the shelter can be controlled.) _____

Closure Requirement

Dimensions: _____ x _____

_____ x _____

_____ x _____

_____ x _____

- c) Ventilation equipment?
Is shelter space adequately ventilated? _____
Can shelter space be adequately ventilated? _____
Are ventilation resources available? _____

- 3) Upgrading resources

a) Are lumber and other materials available for upgrading? Yes___ No___

Locally? ___

b) Are tools and equipment available for upgrading? Yes___ No___

Locally? ___

TASK IV CHECKLIST 2 (contd)

- | | <u>Yes</u> | <u>No</u> |
|--|------------|-----------|
| 4) <u>Earth radiation protection of ceiling.</u> | | |
| a) Can ceiling area be earth protected?
(structural capability) | _____ | _____ |
| b) Is ceiling area accessible for adding
2 ft of soil for radiation protection? | _____ | _____ |
| c) Will owner allow placement of soil for
radiation protection on ceiling? | _____ | _____ |
| d) Are tools and equipment available to
place earth? | _____ | _____ |
| 5) <u>Is earth material available for radiation
protection?</u> | _____ | _____ |
| a) If available for protection at what distance? _____ miles | | |
| 6) <u>Secure storage</u> | | |
| a) Is secure storage for resources, materials
or tools available? | Yes _____ | No _____ |

The following information is to help your representative assess the shelter space & complete the checklists.

Upgrading Requirements

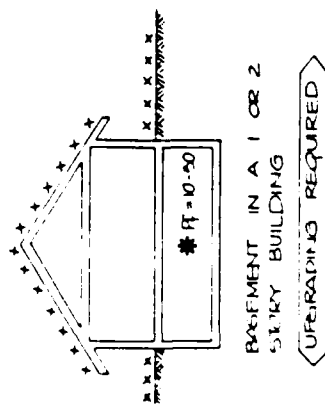
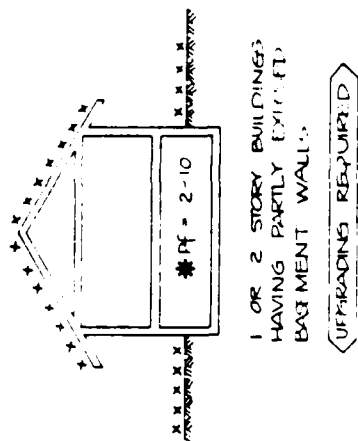
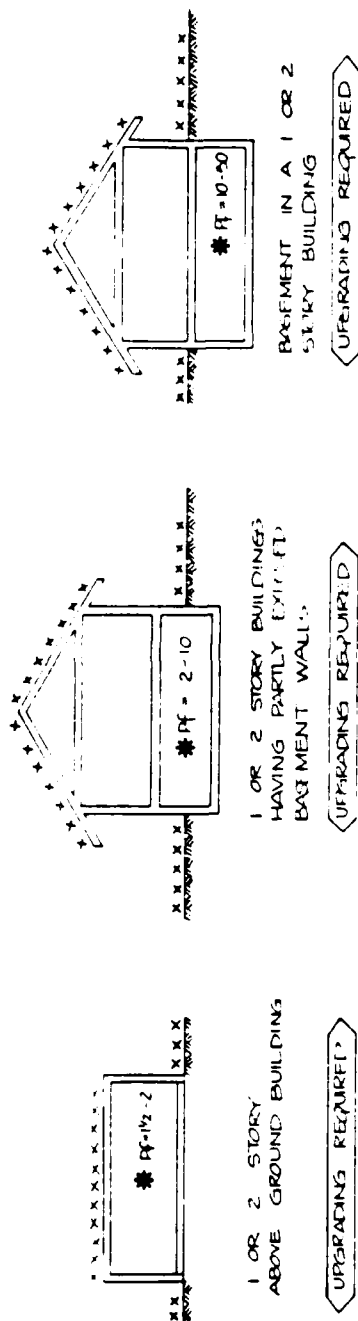
Two considerations are basic to shelter development in Host Areas:

- (1) Adequate radiation protection
- (2) Sufficient structural integrity to support the radiation protection and 2 psi blast overpressures.

The greatest protection from radiation effects can be achieved in below ground, or partially below ground, basement structures. This is shown in Figure 1, and is the basis of the "upgrading" concept for shelter use.

Existing Building Structures

Because below ground structures provide greater radiation protection capability, this manual emphasizes these structures. The majority of below ground structures in Host Areas will be concrete wall basement areas with timber joist and beam ceiling construction. Typical details of this type of construction are shown in Figure 2.



* = OPTIMUM LOCATION IN STRUCTURE.
 XXX = FALLOUT LOCATION ON AND AROUND STRUCTURE.
 PF = RADIATION PROTECTION FACTOR IS THE AMOUNT OF PROTECTION INSIDE A SHELTER OFFERED TO OUTSIDE.

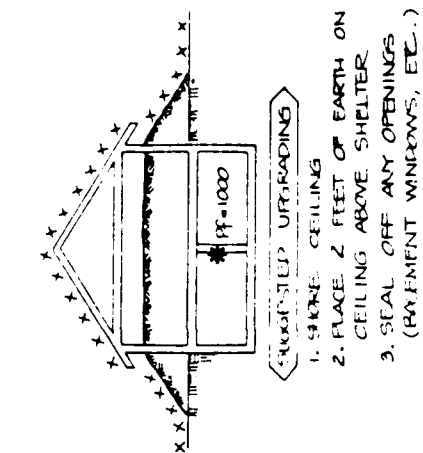
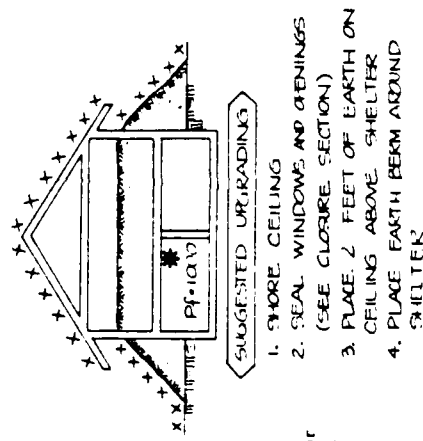
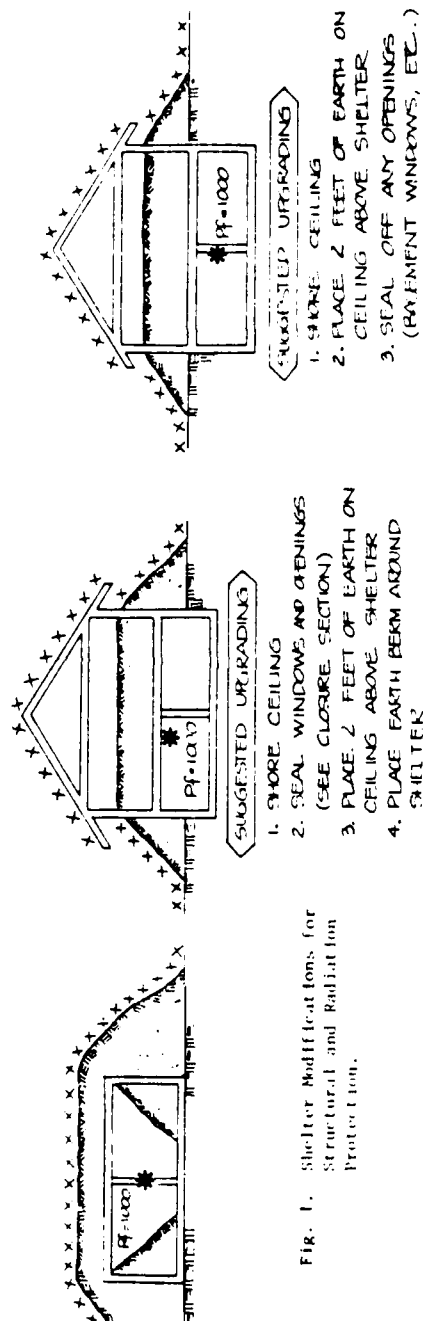


FIG. 1. Shelter Modifications for Structural and Radiation Protection.

- SUGGESTED UPGRADING
1. SHORE CEILING
 2. SEAL WINDOWS AND OPENINGS (SEE CLOSURE SECTION)
 3. PLACE 2 FEET OF EARTH ON CEILING ABOVE SHELTER
 4. PLACE EARTH BEAM AROUND SHELTER

- SUGGESTED UPGRADING
1. SHORE CEILING
 2. PLACE 2 FEET OF EARTH ON CEILING ABOVE SHELTER
 3. SEAL OFF ANY OPENINGS (BASEMENT WINDOWS, ETC.)

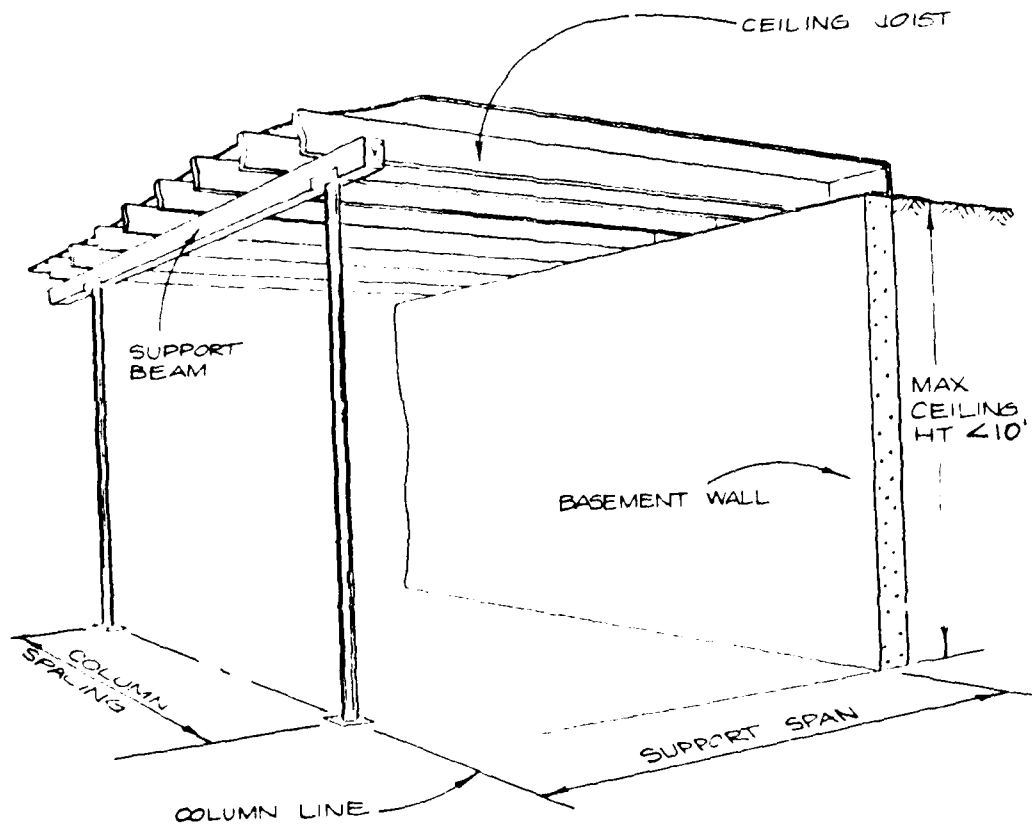


Fig. 2. Timber Joist and Beam Construction.

Characteristics and Construction Details.-- Ceilings are usually plywood or 2-inch thick tongue and groove lumber planks or decking, supported by joists that vary from 2x6 on 12-inch centers to 4x12 on 4-foot centers. Exterior joist supports are usually concrete or block masonry walls, while interior supports may be either steel or wood beams up to 12 inches in depth. Columns are wood posts or steel pipe. Spans between adjacent rows of supports normally vary between 6 and 18 feet. Upgrading commences with shoring to increase the load-bearing capacity to support the radiation protection (Figure 1).

Shoring.-- The recommended method for shoring the basic timber joist and beam structure shown in Figure 2 is to use either:

- (A) Stud wall upgrading, shown in Figure 3, or
- (B) Post and beam upgrading, shown in Figure 4.

The shoring should be spaced at midspan between rows of existing supports. (Drop ceilings will have to be removed.) Additional column supports must be placed at midspan between existing columns.

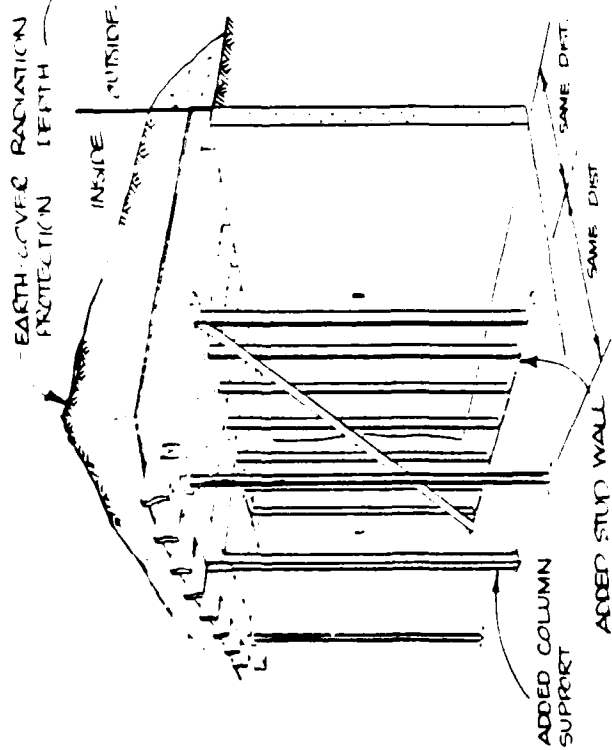
Figures 3 and 4 provide sufficient information to enable your representative to complete the checklists so that a detailed estimate of material, labor, and scheduling can be made.

STUD WALL

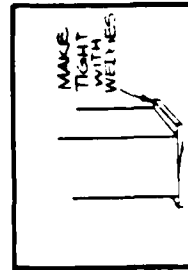
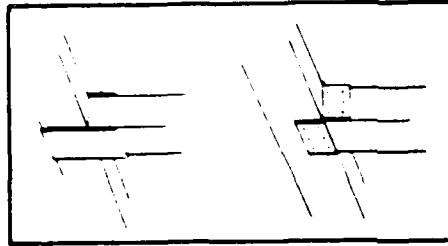
MATERIAL LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Timber (Studs & Plates)		
2. Bracing Material (plywood Sheeting or nom. 1-in. Timber)		
3. Nails		
4. Hammer		
5. Saw		
6. Wedges		
7. Tape measure/yardstick, etc.		
8. _____		
9. _____		
10. _____		

details

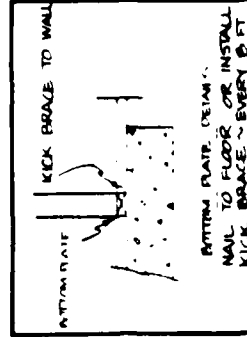
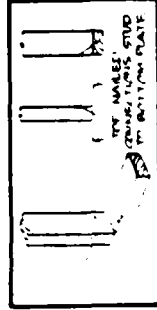
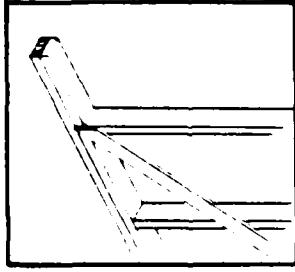


RADIATION PROTECTION DEPTH	DEPTH
100	15 FT
1000	30 FT



COLUMN SUPPORT SIZING	
COLUMN SPACING	QUAN. SIZE
0 TO 10 FEET	1 8"x8"
	2 6"x6"
	5 4"x4"
10 TO 20 FEET	2 8"x8"
	3 7"x7"
	4 6"x6"
	12 4"x4"

STUD WALL SIZING		
SUPPORT SPAN	STUD SIZE	STUD SPACING
0 TO 10 FEET	2"x4"	12" APART
	2"x6"	21" APART
10 TO 20 FEET	2"x8"	14" APART



NAILING SCHEDULE	
BOARD SIZE (MINIMUM)	NAIL SIZE
1" x 4"	10D
1" x 6"	12D
1" x 8"	14D
1" x 10"	16D
1" x 12"	18D
1" x 14"	20D
1" x 16"	22D
1" x 18"	24D
1" x 20"	26D
1" x 22"	28D
1" x 24"	30D
1" x 26"	32D
1" x 28"	34D
1" x 30"	36D
1" x 32"	38D
1" x 34"	40D
1" x 36"	42D
1" x 38"	44D
1" x 40"	46D
1" x 42"	48D
1" x 44"	50D
1" x 46"	52D
1" x 48"	54D
1" x 50"	56D
1" x 52"	58D
1" x 54"	60D
1" x 56"	62D
1" x 58"	64D
1" x 60"	66D
1" x 62"	68D
1" x 64"	70D
1" x 66"	72D
1" x 68"	74D
1" x 70"	76D
1" x 72"	78D
1" x 74"	80D
1" x 76"	82D
1" x 78"	84D
1" x 80"	86D
1" x 82"	88D
1" x 84"	90D
1" x 86"	92D
1" x 88"	94D
1" x 90"	96D
1" x 92"	98D
1" x 94"	100D
1" x 96"	102D
1" x 98"	104D
1" x 100"	106D
1" x 102"	108D
1" x 104"	110D
1" x 106"	112D
1" x 108"	114D
1" x 110"	116D
1" x 112"	118D
1" x 114"	120D
1" x 116"	122D
1" x 118"	124D
1" x 120"	126D
1" x 122"	128D
1" x 124"	130D
1" x 126"	132D
1" x 128"	134D
1" x 130"	136D
1" x 132"	138D
1" x 134"	140D
1" x 136"	142D
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1" x 166"	172D
1" x 168"	174D
1" x 170"	176D
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1" x 184"	190D
1" x 186"	192D
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1" x 212"	218D
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1" x 218"	224D
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1" x 222"	228D
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1" x 228"	234D
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1" x 250"	256D
1" x 252"	258D
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1" x 256"	262D
1" x 258"	264D
1" x 260"	266D
1" x 262"	268D
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1" x 266"	272D
1" x 268"	274D
1" x 270"	276D
1" x 272"	278D
1" x 274"	280D
1" x 276"	282D
1" x 278"	284D
1" x 280"	286D
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1" x 286"	292D
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1" x 978"	984D
1" x 980"	986D
1" x 982"	988D
1" x 984"	990D
1" x 986"	992D
1" x 988"	994D
1" x 990"	996D
1" x 992"	998D
1" x 994"	1000D
1" x 996"	1002D
1" x 998"	

POST & BEAM

MATERIAL LIST

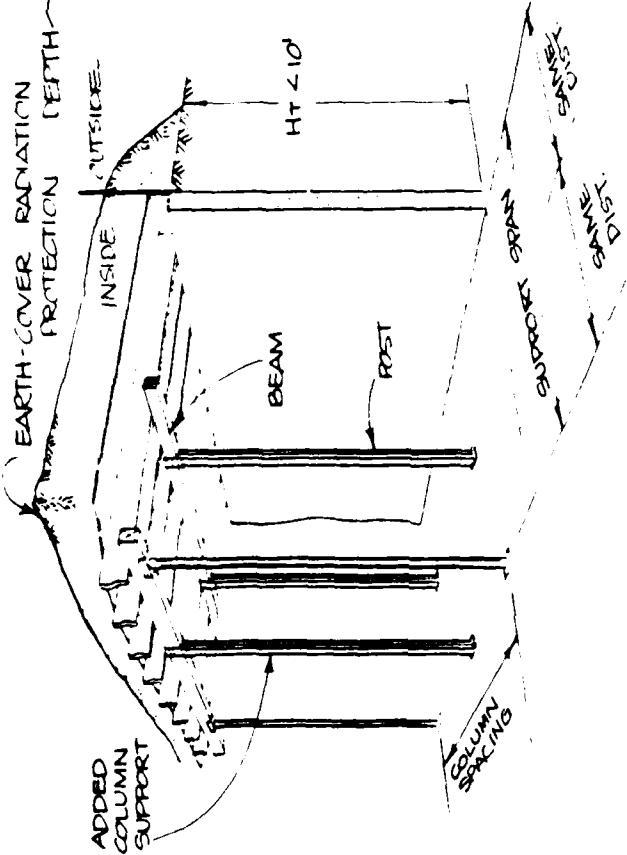
Required

1. Timber (Posts)
2. Timber (Beams)
3. Nails
4. Hammer
5. Saw
6. Wedges
7. Tape measure/yardstick, etc.
8. _____
9. _____
10. _____

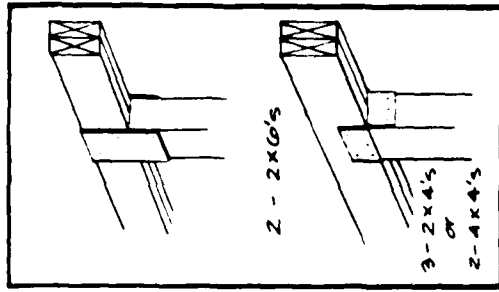
Quantity

Available

details

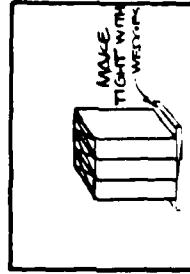


RADIATION	DEPTH
10"	15 FT
12"	30 FT



BOARD SIZE (NOMINAL)	NAIL SIZE
1 x 6	6d
2 x 6	8d
3 x 6	10d
4 x 6	12d

* where b = width of boards
 when b = 2 in, use 2 nails
 when b = 4 in, use 3 nails
 when b = 6 in, use 4 nails



COLUMN SPACING	QUAN.	SIZE
0 TO 10 FEET	1	8x8"
	2	6x6"
	5	4x4"
10 TO 20 FEET	2	8x8"
	3	7x7"
	4	6x6"
	12	4x4"

POST AND BEAM SIZING	BEAM SIZE	POST SIZE	POST SPACING
SUPPORT SPAN	SIZE	SIZE	SPACING
0 TO 10 FEET	2-2x6	3-2x4's	4'
10 TO 20 FEET	2-2x6	2-4x4's	3'

WOOD CONSTRUCTION-Floors TIMBER JOIST

Fig. 4. Post & Beam Upgrading.

Task 5 Detailed Estimate of Material, Equipment, Labor, and Scheduling

Use the data gathered on the Task IV checklists 1 and 2 to develop a materials and equipment list, and to determine the schedule to be met to prepare the shelter space to house your people and supplies.

You will need material and equipment for:

- (1) Shoring the floor above to hold two feet of earth (Figures 3 and 4)
- (2) Closures for all the windows, entrances, and other openings (Figures 7 through 10)
- (3) Covering the floor above with two feet of earth and to berm the outside walls to the same height (Figure 8).

The remainder of this section provides information needed for this task.

Shelter Closures

The majority of shelter spaces will require some form of access-closure in addition to special closures to seal the spaces. Any basement upgraded for a Host Area shelter will probably have a stairway, windows, doors, ventilation ducts, or access openings.

These openings can be bridged by using a number of readily available materials, such as wood or steel. Examples of wood that may be used are fence posts, spare power poles (cut up), railroad ties, solid core doors, and wood beam and plank pieces. Steel plate and rolled beam sections may also be used. Table 3 lists alternative materials that may be considered for closures.

TABLE 3: CLOSURE MATERIALS

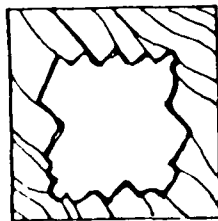
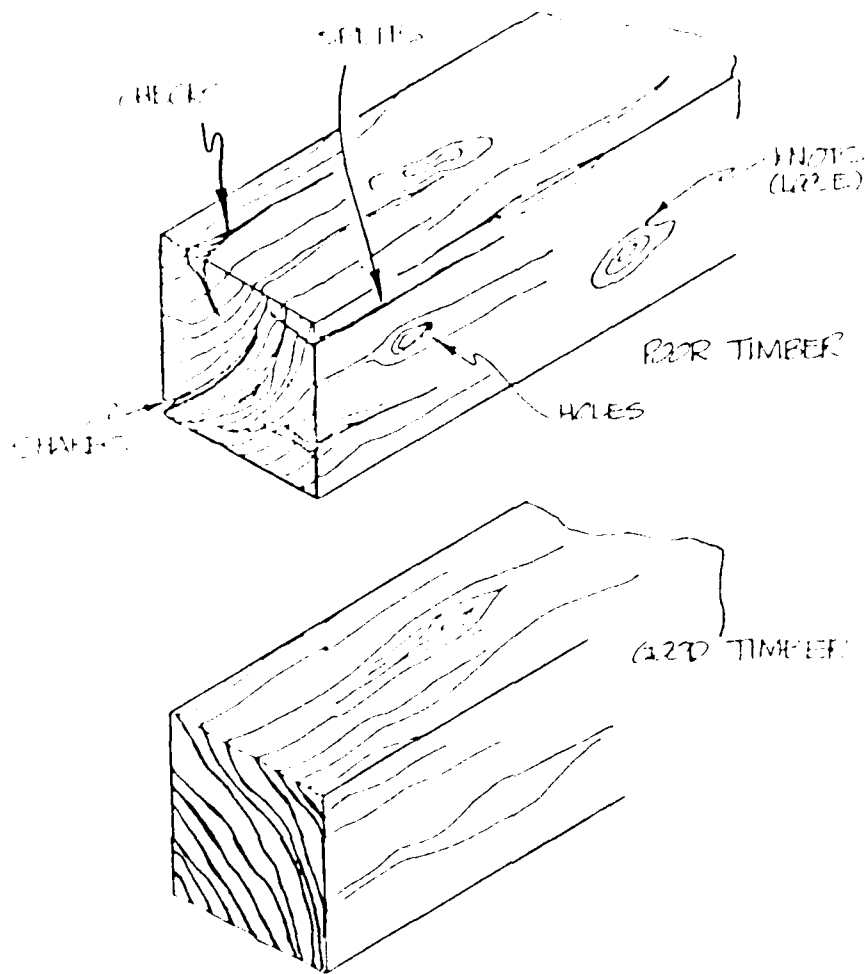
Steel doors	Telephone or power poles
Wood doors (solid)	*Filled sandbags
Toilet doors and partitions	*Filled paper bags
Steel cover plates	*Filled paper boxes
Desk and table tops	*Filled plastic garbage cans
Railroad ties	Brick or concrete block
Plywood	*Filled oil or paper drums
Wood, steel, or concrete fence posts	*Sand or earth

The use of wood products for closures requires that material variations affecting wood strength be considered. Wood fence posts, power poles, or railroad ties can be splintered or can exhibit rot or other defects. Generally, poor timber is utility grade when new, and may have loose knots or knotholes. Poor timber may have checks, shakes, or splits. These features are illustrated in Figure 5.

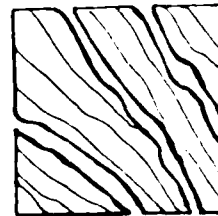
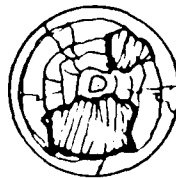
Comparison of various materials that may be used to construct closures is shown in Figure 6. This figure indicates the maximum opening width that may be spanned without intermediate support for various materials. This chart can be used in two ways:

1. Enter the chart with the minimum opening width, and list the type and thickness of materials that could be used for closures. The list could then be used to determine the most available materials.
2. Enter the chart with a known available resource and determine the width of closure that may be accommodated. This alternative will indicate if a further search for closure resources is required.

It must be remembered that all shelter closures also require radiation protection. The most straightforward approach is placing earth over the closure if



ROTTED TIES OR POSTS



SPLINTERED POSTS / POLES TIES

Fig. 5. Factors Affecting Wood Strength.

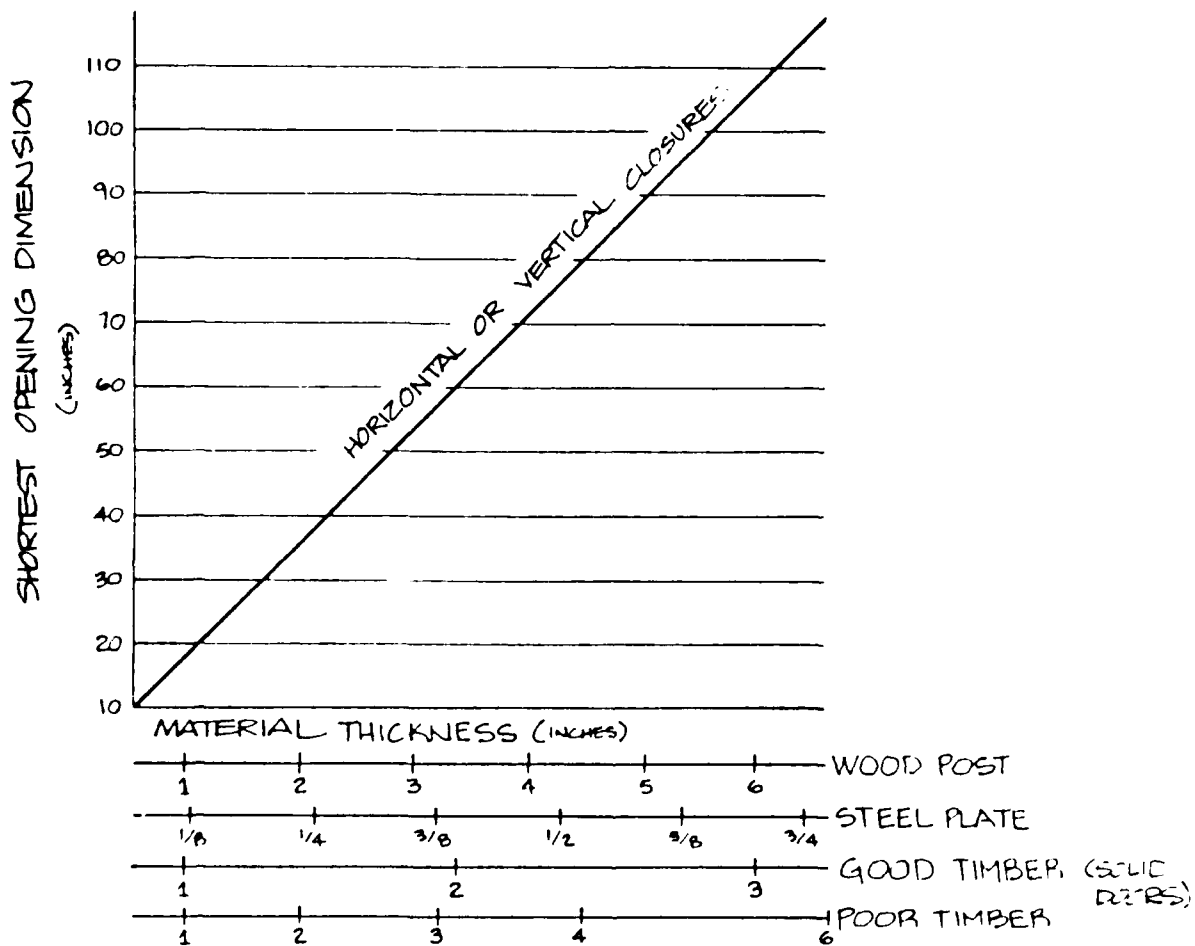


Fig. 6. Material Thickness Required to Close Various Openings (2 psi overpressure).

it is horizontal, or piling earth against the closure if it is vertical. The earth placement may require significant personnel time or earth-moving equipment, particularly over basement floors enclosed by structural improvements. One expedient method is to place the earth (or sand) in containers such as sandbags, paper bags, cardboard boxes, or other containers.

Figures 7 - 10 illustrate different types of basement closures and placement of earth radiation protection.

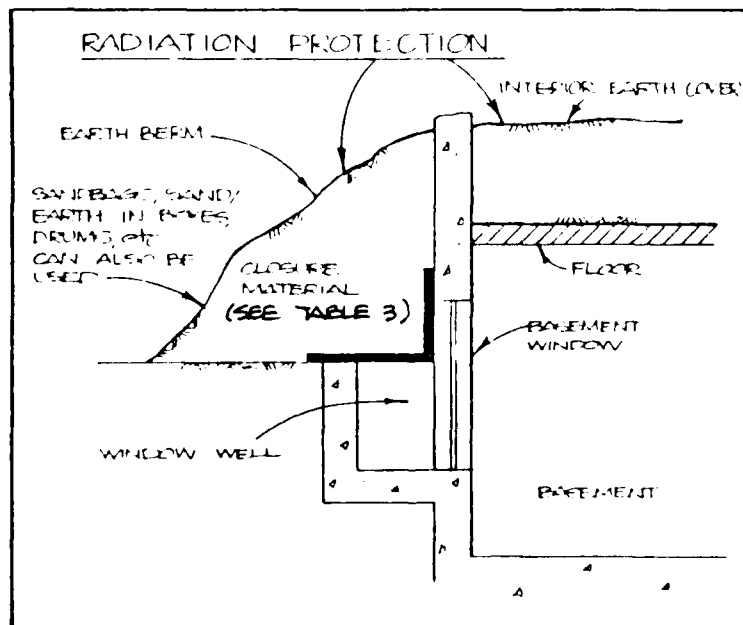
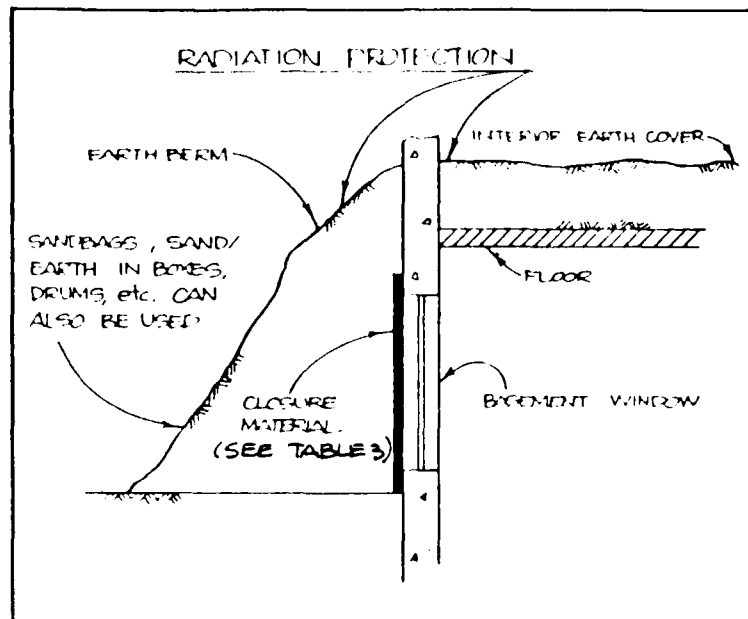


Fig. 7. Window Closures.

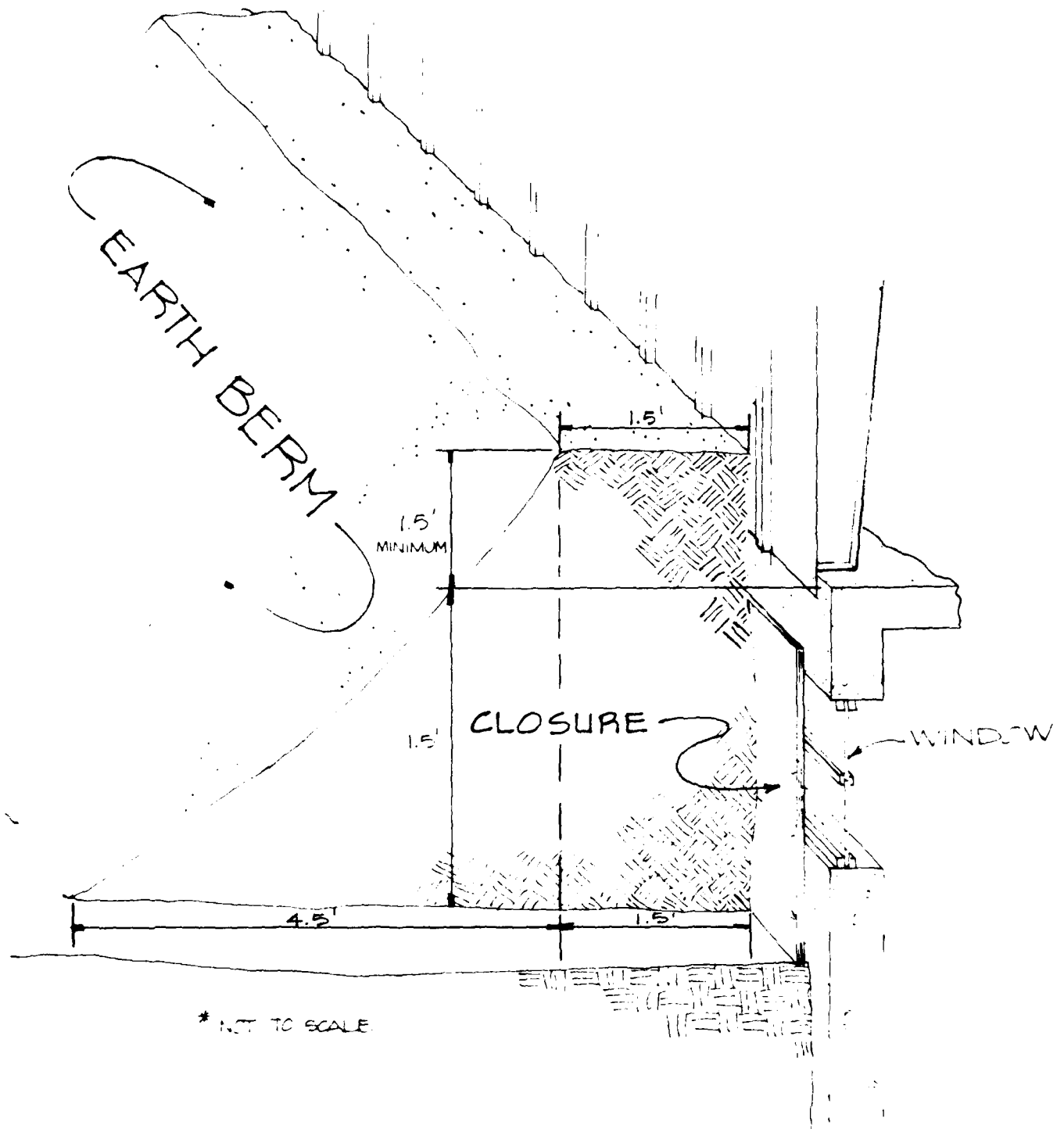


Fig. 8. Window Closure.

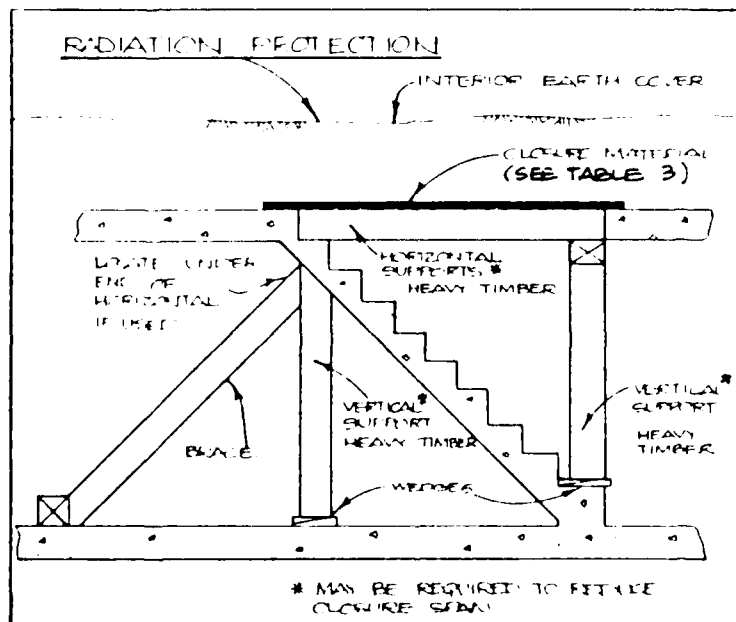
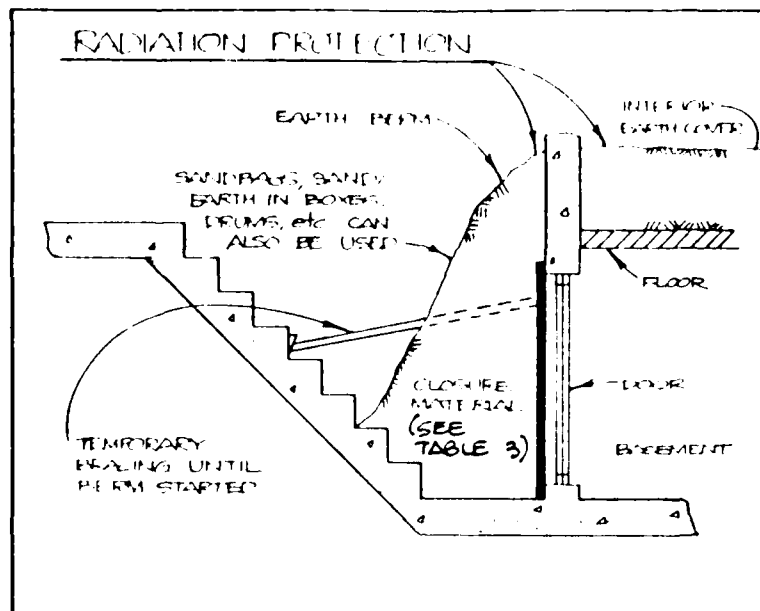


Fig. 9. Stair and Door Closures.

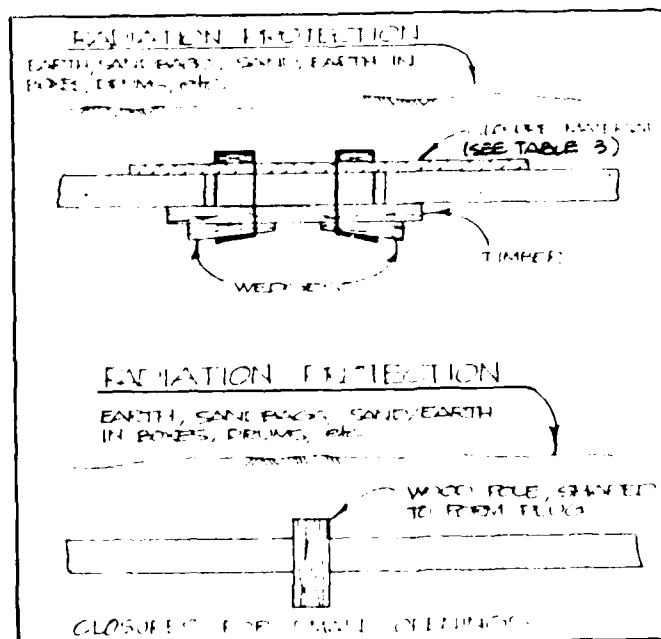
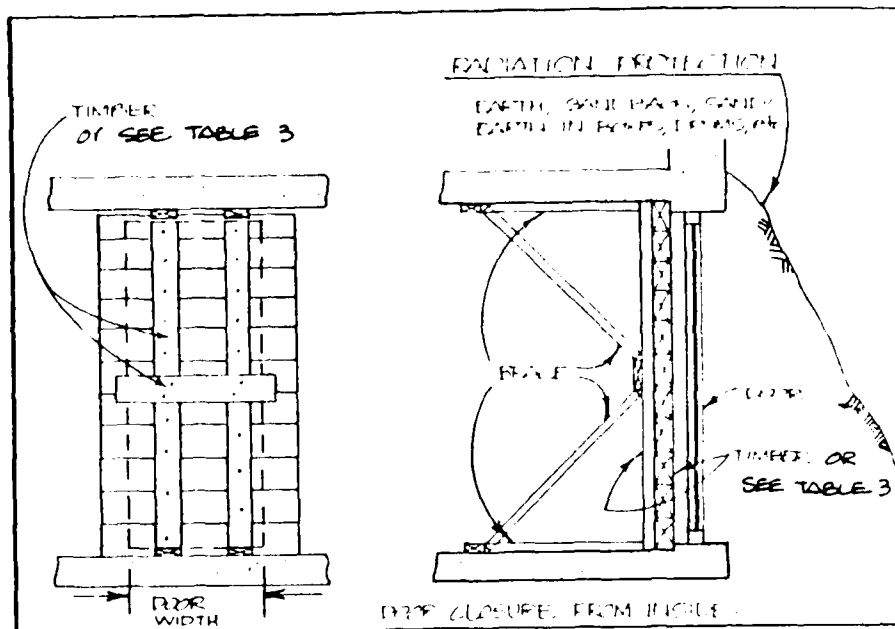


Fig. 10. Door and Small Opening Closures.

Radiation Protection

The most readily available resource to protect a sheltered population against the long-term effects of radiation is a mass of earth. One and one-half to two feet of earth will provide a protection factor of 100.

Movement and placement of earth around the perimeter of a building area selected as a Host Area shelter may be a significant task. In order to provide an adequate estimate of time for earth radiation protection, Figures 11 and 12 are provided.

As an example, a 50-person basement shelter allowing 25% of shelter space for stocking and supplies can be analyzed as follows:

$$50 \text{ person} \times 10 \text{ sq ft} \times 1.25 = 625 \text{ sq ft of area, or} \\ \text{a shelter 25 feet square.}$$

$$625 \text{ sq ft} \times 2 \text{ ft deep} \div 27 = 46 \text{ cubic yards.}$$

Using Figure 11 and assuming the dimensions of the exterior earth berm shown in Figure 8:

$$3 \times 1.5 + 3 \times 4.5 \div 2 = 11.25 \text{ ft}^3 \text{ per foot of berm,} \\ \text{or } 0.42 \text{ yd}^3 \text{ per foot of berm}$$

If berming is required on two sides of the shelter,

$$0.42 \text{ yd}^3 \times 2 \times 25 = 21 \text{ cubic yards.}$$

Thus, a total of $46 + 21$, or 67, cubic yards of earth is required. Placement of this material by hand labor would take 24 man-hours of time, or three men for an 8-hour workday (Figure 11). For larger shelters or shelters where equipment may be used to place the earth radiation protection, Figure 12 may be used.

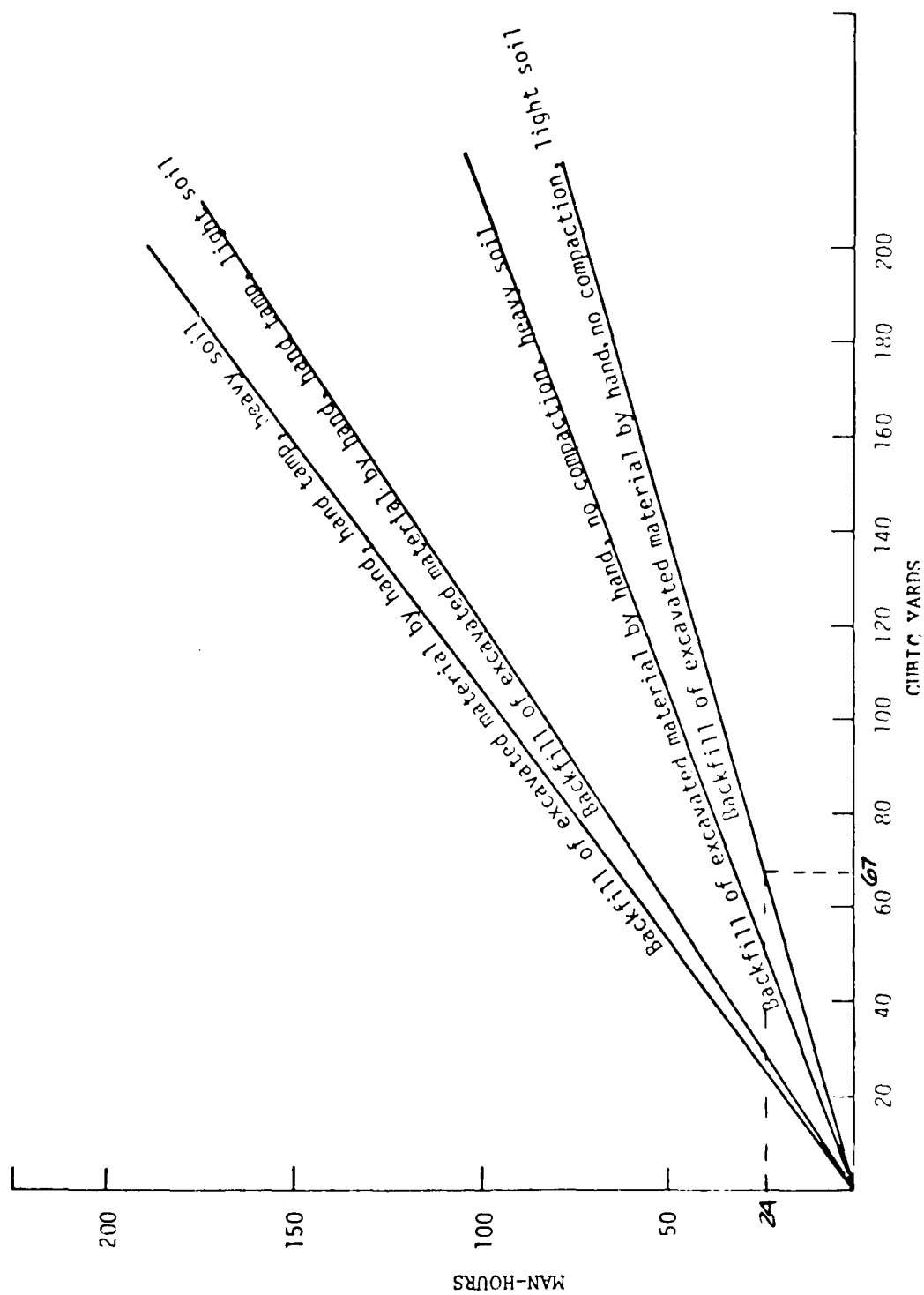


Fig. 11. Time Requirements for Hand Earth Moving Processes.

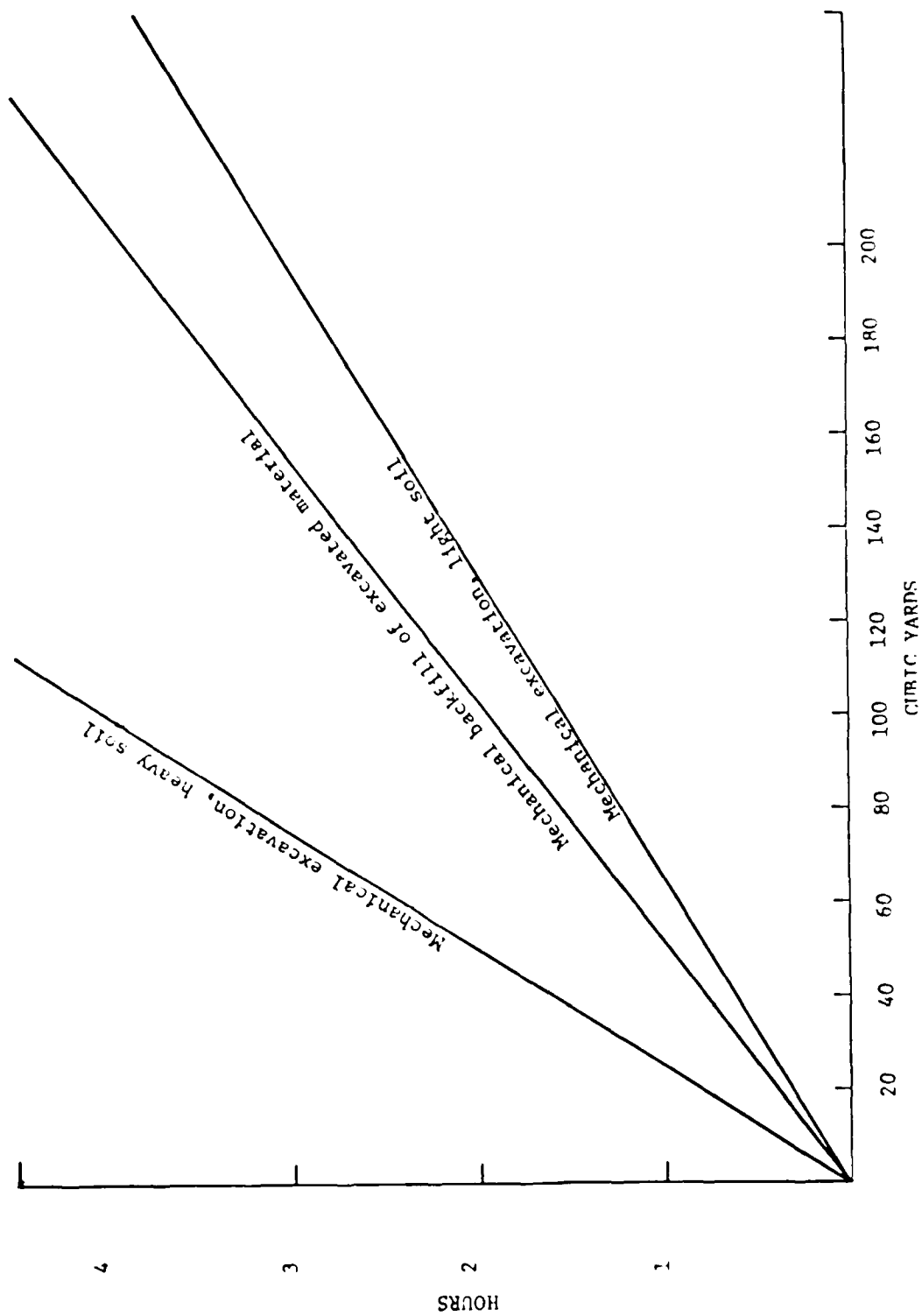


Fig. 12. Time Requirements for Mechanical Earthmoving Processes.

Task 6: Logistics Preparation and Upgrading Sequence

The planning and analysis in Tasks 1 through 5 have provided for selection of upgradable shelter space and data on available resources and supplies for upgrading. This planning has provided:

- o An evaluation of the shelter(s) assigned and/or selected to determine upgrading methods and resources needed.
- o Shelter stocking lists based on shelteree numbers and needs.
- o Upgrading development methods for preparing various alternative shelters.

Manpower Assignments

Each industry providing a Host Area shelter plan for its employees should assign personnel to shelter tasks based on their experience in expediting projects and providing alternate solutions to problems as they arise. Shelter preparedness will require a team of supervisory industry personnel to accomplish the upgrading, stocking, and movement to shelter. A pre-assigned management organization can best implement the development of Host Area shelters.

Upgrading Sequence for Post-Warning Implementation

Upgrading of shelter space, whether an existing basement or expedient structure, requires an organized sequence of steps to implement efficiently (i.e., time and resources) after warning of an impending attack.

- o The shelter coordinator should provide maps and sketches of the Host Area site to all other shelter team personnel.
 - (1) A detailed road map to direct people to the Host Area shelter site.
 - (2) A site sketch sheet showing the shelter location at the site, with address, etc.
 - (3) A building sketch sheet showing where the shelters are within the confines of the shelter site.

Suggested examples of the site sketch sheet and the building sketch sheet are enclosed.

- o The shelter manager in conjunction with other team members should complete the following checklists:

- (1) **Checklist 1.**-- Equipment and Resources for Upgrading; acquire resources if not already available.
- (2) **Checklist 2.**-- Upgrading Sequence Priority Time Frame Analysis.
- (3) **Checklist 3.**-- Expedient Shelter Option Burial Priority Time Frame Analysis. (To be used only if expedient shelter option is selected. See Appendix A.)

Note: Shelter preparation and upgrading (Checklists 2 and 3) are designed to be completed within the 72-hour time frame. If the total elapsed time exceeds the 72-hour time frame: (1) the shelter upgrading development plan may need to be re-assessed; or (2) more personnel, equipment, or resources may be needed, to reduce the total elapsed time to less than 72 hours. The lower the total elapsed time, the better off the sheltered population.

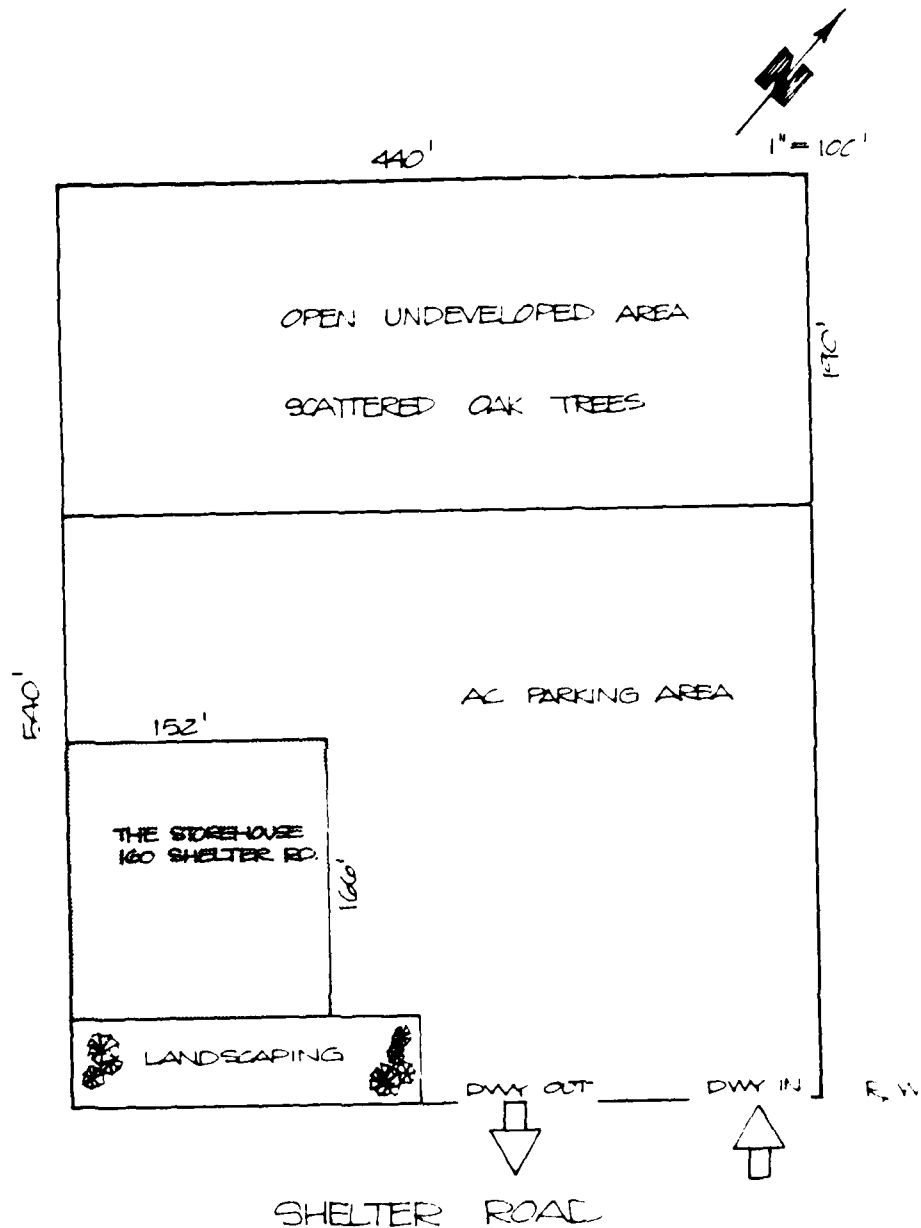
SITE SKETCH SHEET

FACILITY NUMBER 27T4

DATE 3-1-80

BUILDING NAME THE STOREHOUSE

SURVEYOR 22



N. Arrow ☒ Distance to Soil 200' Mut. Shielded Wall No
 Access Obstructions NONE Changes in grade 1' ± Frontage Rd. YES

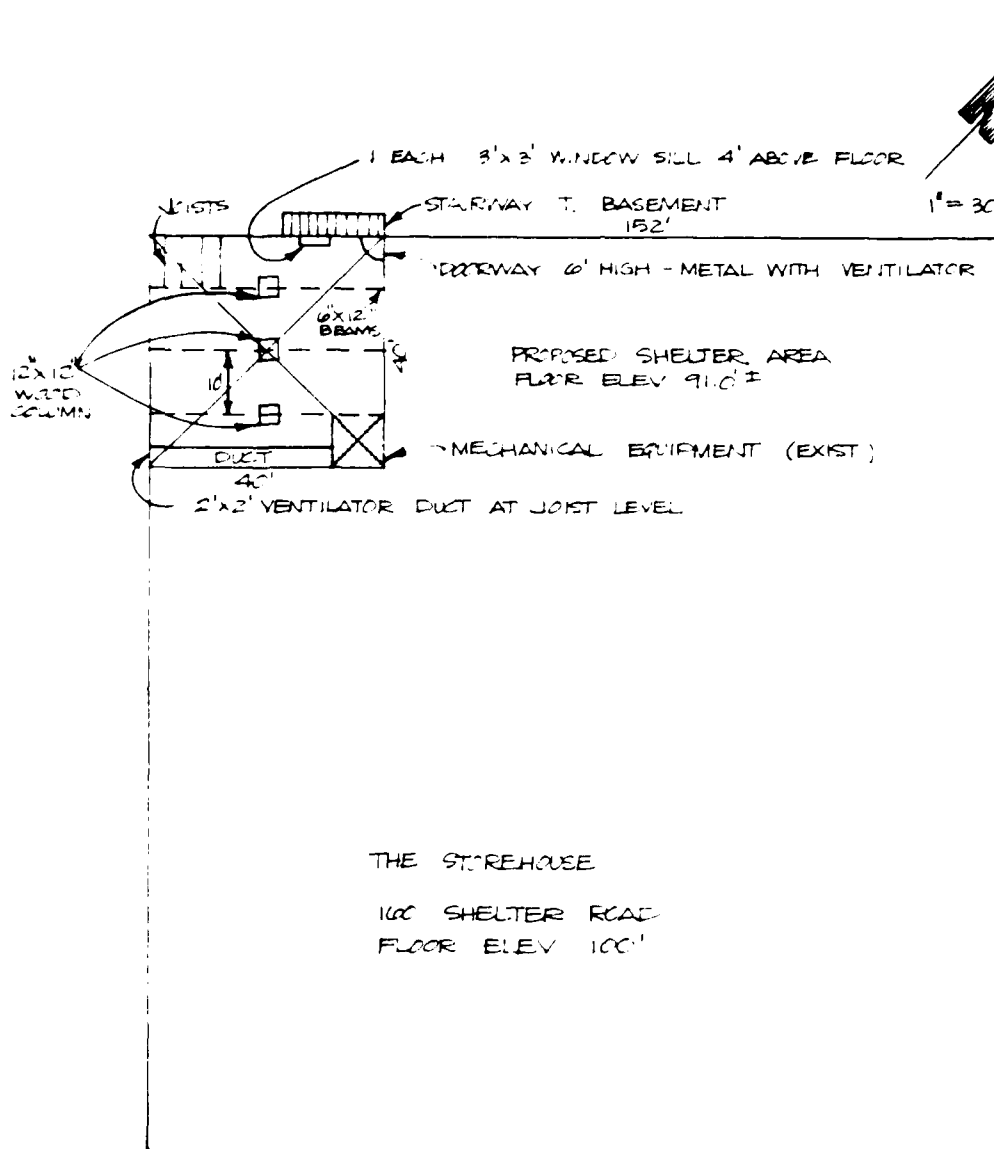
BUILDING SKETCH SHEET

FACILITY NUMBER 27T4

DATE 3-1-85

BUILDING NAME THE STOREHOUSE

SURVEYOR 22



No. Arrow V Ext. Wall Mat. CONC BLOCK Ext. Wall Height 6' ±
 Aperture Dim. sill/height/width Roof Slope N/A Roof Mat. N/A
 Detail Beams 6x12" Joist Location & Dim. 2"x10"
 1st Flr Elev. +1' Roof Overhang 3' Joist O.C. 16" Joist Span 10'
 First Floor Mat. 2" T & G Second Floor Mat. N/A BASEMENT CONCRETE

HOST AREA SHELTERS

TASK VI EQUIPMENT AND RESOURCE CHECKLIST 1

Item	Amount Needed	Amount Available	Amount to Obtain
Portable generator with fuel	1 each		
Portable lights with cords	3 to 4 each		
Power saws with cords	2 or more		
Wheelbarrow	2 or more		
Pick & Shovels	many		
Hammers	many		
Nails & Hardware	From Task IV		
Measuring and marking equipment	3 sets		
Handsaw	3 or more		
Misc. jacks, clamps, hardware			
<u>Lumber*</u>	From Task IV Materials List: (Enter quantity)		
2 x 4			
2 x 6			
1 x 4			
1 x 6			
4 x 6			
4 x 4			
Wood wedges (pairs)			
1/2" Plywood 4' x 8' sheets			
5/8" Plywood 4' x 8' sheets			
3/4" Plywood 4' x 8' sheets			
<u>Other Needs</u>			

* Linear feet unless otherwise indicated.

HOST AREA SHELTERS

TASK VI CHECKLIST 2

UPGRADING SEQUENCE PRIORITY CHECKLIST	ESTIMATED TIME FRAME			
	EQUIPMENT NEEDED	EQUIPMENT TIME	MANHOURS REQUIRED	NO OF PERSONNEL
1) Obtain resource list, re-sources - move to shelter for upgrading.	Trucks			
2) Remove debris, clean shelter & surrounding area.	Trucks & Tools			
3) Lay out upgrading (shoring, closures, radiation protection), make initial checks of materials, cut materials and check fit.	Power tools Hand tools & Supplies			
4) Complete upgrading including entry structures.	"			
5) Complete movement of earth for radiation protection.	Dozers, Loaders Wheelbarrows Buckets, Shovels etc.			
6) Start ventilation equipment installation	Power tools Hand tools & Supplies			
7) Install interior shelter features - toilets, shelves	Power and Hand Tools			
8) Clean up & stock shelter with all food and supplies	Misc. Hand Tools			
9) Provide for waste disposal area.	Misc. Excavation Tools			

HOST AREA SHELTERS

TASK VI CHECKLIST 2

UPGRADING SEQUENCE PRIORITY CHECKLIST	ESTIMATED TIME FRAME				TOTAL TIME USED-HOURS
	EQUIPMENT NEEDED	EQUIPMENT TIME	MANHOURS REQUIRED	NO OF PERSONNEL	
10) Implement Shelter management program.					
11) Expedient shelter burial if not completed previous- ly (from Checklist 4). Eliminate Item 5 above.					
TOTAL ELAPSED TIME ≤					72.0 hrs.

HOST AREA SHELTERS

TASK VI CHECKLIST 3

EXPEDIENT SHELTER OPTION BURIAL PRIORITY	EXPEDIENT SHELTER ESTIMATED TIME FRAME				TOTAL TIME USED-HOURS
	EQUIPMENT NEEDED	EQUIPMENT TIME	MANHOURS REQUIRED	NO OF PERSONNEL	
1) Provide transportation and personnel to move expedient shelter location.	Trucks, Cranes, Forklifts				
2) Obtain equipment and excavate for burial, partial burial or berms, including entries.	Backhoes, Bulldozers, Front Loader				
3) Provide modification to structure for entry holes for ventilation and access of shelterees.	Special tools and equipment				
4) Place shelter in excavation, install entry, ventilation and appurtenant items such as floors.	Cranes or other lifting equipment				
5) Install large shelter stock items and backfill and berm structure.					
TOTAL ELAPSED TIME					*

* Transfer to Item 11 Checklist 2 if not completed prior to D-Day minus 3.

SUMMARY

This manual provides a procedure to develop shelter space that involves coordination in planning and conversion of commercial space in use in another community. The conversion must provide adequate, livable shelter space within a 72-hour time frame. Some industries may prefer to choose their own shelter area and locate it on private property, perhaps where there are no structures at present. Appendix A provides information for this alternative. Appendix B provides data on shelter management.

The time is D-day minus 3, your industry has just received a 72-hour warning to complete evacuation and preparation of a shelter for a two-week stay. Are you prepared to do it?

GLOSSARY AND LIST OF NOTATIONS

- AS BUILT — Structure prior to upgrading
- UPGRADING — Strengthening of a structure to withstand unusual (larger than normal) loads
- BLAST WAVE — A wave of sudden pressure change that moves outward from an explosion, creating larger than normal loads
- OVERPRESSURE — The sudden pressure change caused by a blast wave, measured in psi. One psi is equivalent to a column of water 2.3 feet high or a column of soil 1.4 feet high
- RISK AREA — Region that is subjected to blast pressures over 2 psi
- HOST AREA — Region that is subjected to blast waves with pressures of 2 psi or less
- HOST AREA
SHELTER — A shelter that will protect the inhabitants to 2 psi or better (equivalent to a column of water 4.6 feet high, or a column of soil 2.3 feet high)
- P_f — Protection Factor (radiation). A number that indicates how many times less severe the effect of radiation is in a shelter than that received when there is no protection
- PSF — Pounds per square foot (an indication of pressure loading; a one-foot thick layer of soil would apply a pressure of about 110 psf)
- PSI — Pounds per square inch (144 psf = 1 psi)

APPENDIX A

**ALTERNATIVES TO CIVIL DEFENSE ASSIGNED SPACE
EXPEDIENT SHELTER OPTIONS
SHELTER ENTRY AND CLOSURES FOR UNDERGROUND SHELTERS**

This is an alternate Booklet 3
for the case of no
Host Area assignment

ALTERNATIVES TO CIVIL DEFENSE ASSIGNED SPACE

- o Select a host area for evacuation of your industry personnel and their families. The Host Area should be in a rural environment located away from large, industrialized urban areas, military installations, or seats of government. If you do not already have access to a suitable location, poll friends, relatives, business associates, as well as employees. (Perhaps you can exchange the capabilities you bring for access, or agree to assign the shelter and all the improvements to the host for his own use after the crisis and its associated fallout environment have subsided to safe levels.
- o Determine if upgradable space is available, such as a basement building area that is of sufficient size and that may be upgraded to shelter all personnel.
- o Select an alternative expedient shelter if upgradable space is unavailable. (See checklist pages 3 and 4)
- o Develop upgrading methods, and obtain all resources and equipment needed to implement the scheme.
- o Provide shelter stocking resources, develop logistics for resources, based on shelter requirements.

EXPEDIENT SHELTER OPTIONS

Existing basement structures may be limited in some designated Host Areas. It will be necessary in these situations to use expedient shelters. There are a number of options to be considered, including adapting host area in-place facilities such as tanks, storm drains, utility vaults, or alternatively obtaining semi-portable structural facilities for use as buried shelters. Options that can be buried and used as shelters include railroad cars, maritime shipping containers, and other specially built modular structures. Table A-1 lists options that may be implemented without upgrading, and Table A-2 lists options that require some form of upgrading. The upgrading method recommended is post and beam, since it provides the most efficient use of shelter space.

Expedient shelter options discussed and data presented are as follows:

Buried tanks	page A-7
Railroad Cars	page A-8
Storm drain systems	page A-12
Other shelter types	page A-17

Expedient shelter fact sheets are provided for each option to help in selecting and implementing the options for shelters. At the end of this section an estimate of preparation time for some of the expedient options is provided (Table A-4, page A-27).

The shelter options discussed herein are just a few of the potential possibilities for Host Areas. Each plant superintendent and/or industry planner should conduct a survey that will provide him the best shelter choice. The formation of mutual aid pacts with nearby industries or suppliers to jointly develop Host Area shelters also should be considered.

HOST AREA SHELTERS

EXPEDIENT SHELTER OPTION CHECKLIST

(Refer to following pages for various options)

- 1) Is a suitable site available? _____
- 2) Is an expedient shelter available? _____
 - a) Existing buried structure - _____ Onsite _____
Adjacent off site _____
 - b) New option to be buried: Tank _____
Railcar _____
Vault _____
Container _____
Other _____
- 3) Transportation to site - _____ Easily relocated _____
Special transportation required _____
- 4) Type of transportation equipment needed:
 - (a) _____
 - (b) _____
- 5) Space upgrading - Length _____ Width _____ Height _____
 - a) Type of upgrading - _____ Post & Beam* _____
 - b) Number of exits, windows, and other passages for closures required? _____

Dimensions: _____ x _____
_____ x _____
_____ x _____
_____ x _____

* Post and beam upgrading of expedient shelters will allow a more efficient use of shelter space.

EXPEDIENT SHELTER OPTION CHECKLIST (contd)

c) Ventilation equipment

Is shelter space adequately ventilated? _____

Can shelter space be adequately ventilated? _____

Are ventilation resources available? _____

6) Upgrading resources

a) Are lumber and other materials available for upgrading? Yes ____ No ____
Locally? _____

b) Are tools and equipment available for upgrading? _____
Locally? _____

7) Is burial site available? _____

a) Is potential debris pileup a problem? _____

b) Is high ground water a problem? _____

8) Is secure storage for resources, materials and tools available? _____

TABLE A-1

POTENTIAL HOST AREA SHELTERS THAT WITHSTAND 2 PSI WITHOUT UPGRADING

Shelter Option Description	Where to Locate, Whom to Contact
Cylindrical tanks	Look in Yellow Pages of telephone book for: (1) Tanks, Metal;
Steel Tanks	(2) Tanks, Used;
Fiberglass Tanks	(3) Tanks, Fiberglass;
	(4) Tanks, Repairing;
	(5) Tank Lining and Coating.
Surplus Railroad Cars	Obtain from railroad equipment and supply company. For example, the Purdy Company sells surplus rail cars and equipment.
Refrigerator Box cars	
Storm Drainage Facilities	City and county public works departments and flood control districts. U.S. Geological Survey topographical maps and other special purpose maps (not road or street maps.)
Manholes	
Large pipe culverts*	
Box culverts*	
Mine Shafts and Tunnels	U.S. Geological Survey geologic maps. State Division of Mines publications.
Mine Tunnels*	Road and rail maps
Rail & highway tunnels*	
Other Options	
Concrete Utility Vaults	Concrete products manufacturers in Yellow Pages.
Reinforced Concrete Pipe	Yellow Pages under Concrete Pipe Products, Culverts, Manufacturers and Pipe.
Concrete Tanks	Yellow Pages under Tanks — Concrete.

- * Box culverts and tunnels require extensive closure systems to prevent longitudinal entry of blast effects. (Two psi won't endanger occupants directly, but can shatter glass.) It is suggested culverts and tunnels be fitted with 40 psi blast doors as the shelter itself is likely to be able to survive this pressure.

TABLE A-2
POTENTIAL HOST AREA SHELTERS THAT REQUIRE UPGRADING

Shelter Option Description	Where to Locate, Whom to Contact	Upgrading Method
Surplus Railroad Cars		
Caboose	Obtain from railroad equipment and supply company. For example, the Purdy Company sells surplus	Post and Beam Lateral span Plywood sheathing
Passenger		
Other Options		
Surplus Maritime Shipping Containers	Container manufacturing and repair companies; obtain from Containerization International Yearbook	Post and Beam Lateral span
Trailer, Truck Van Bodies	Yellow Pages under Truck Bodies and Truck Equipment and Parts.	Post and Beam Lateral span
Metal Newspaper Storage bins	Look in Yellow Pages under Waste Paper	Post and Beam Lateral span

EXPEDIENT SHELTER FACT SHEET BURIED TANKS

Buried tanks provide ideal Host Area Shelters. A typical installation is shown in Figure A-1.

- (1) Any steel tank newly manufactured and unused that is ordinarily buried.
- (2) Any other types of new non-pressure tanks such as fiberglass fuel tanks or septic tanks.

Limitations

- (1) Do not use tanks that have been previously used for fuel storage, toxic chemicals, or other hazardous materials.
- (2) Do not bury tanks in areas of high ground water, as tanks may rise out of ground owing to fluid uplift.

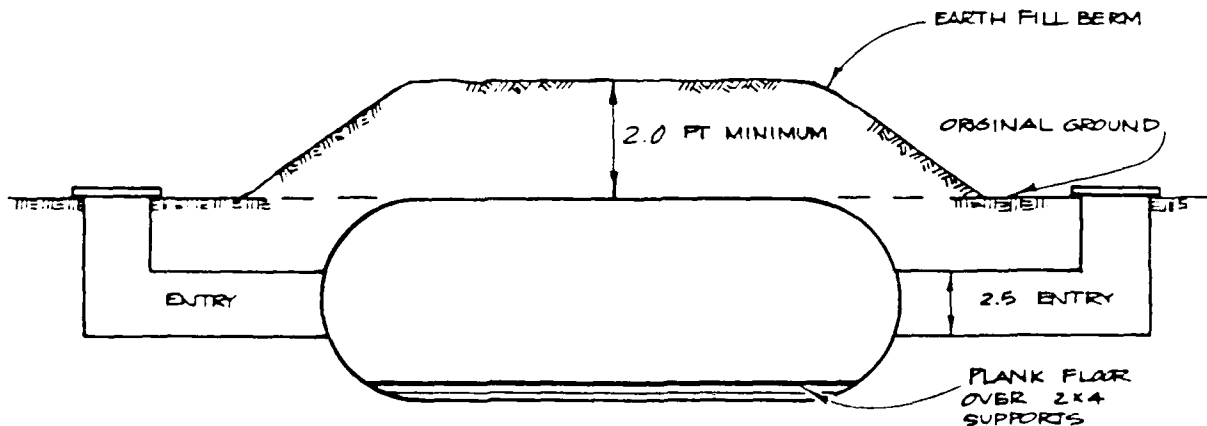


Figure A-1. Typical Installation (Any Buried Tank)

Note: Entry can be fabricated using 30-inch diameter corrugated metal, concrete pipe, or wood framing. See Shelter Closures in this Appendix.

EXPEDIENT SHELTER FACT SHEET

RAILROAD CARS

Certain types of railroad cars can provide ideal Host Area shelter space without upgrading. Other types require minor upgrading. The railcar options discussed are limited to these types:

- o Box cars and refrigerator cars require no upgrading.
- o Caboose and passenger car types require post and beam upgrading with closures on windows and other openings.

General Notes

- (1) All cars would have their undercarriages, couplers, and miscellaneous non-essential frame materials removed.
- (2) Refrigerator cars have access hatches on the top. Thus, access and ventilation can be provided using the hatches, whether the cars are buried upright or on their sides.
- (3) Box cars require access and ventilation holes to be cut through the sides or ends of the cars, or modifications made to existing access doors.
- (4) Caboose and passenger cars will require closures over existing window areas to prevent blast damage, even at 2 psi.
- (5) The upgrading scheme best suited to railcars is post and beam type (see Fig. A-10) since more efficient space utilization occurs.
- (6) Heavy capacity lift equipment is required to place cars in an excavation.

Advantages of Implementing Railcars

- (1) They are numerous. See Table A-3.
- (2) Railcar types suggested for expedient shelters are all constructed with steel frame exteriors. Steel or wood interiors vary with car type.

TABLE A-3. TYPICAL ANNUAL RAILCAR AVAILABILITY

Type of Car	Total No. of Cars Retired Annually	10% of Car Bodies Usable Without Repair	20% of Car Bodies Estimated Repairable	Total Potential Car Bodies Usable	Estimated Total People Sheltered
Box	34,600	3,460	6,920	10,380	207,600
Refrigerator	960	96	192	288	5,700
Caboose	960	96	192	288	4,300
Passenger	450	45	90	135	4,000
Total Cars	<u>36,970</u>	<u>3,697</u>	<u>7,394</u>	<u>11,091</u>	<u>221,600</u>

Details of buried railcar shelters are shown on the following pages.

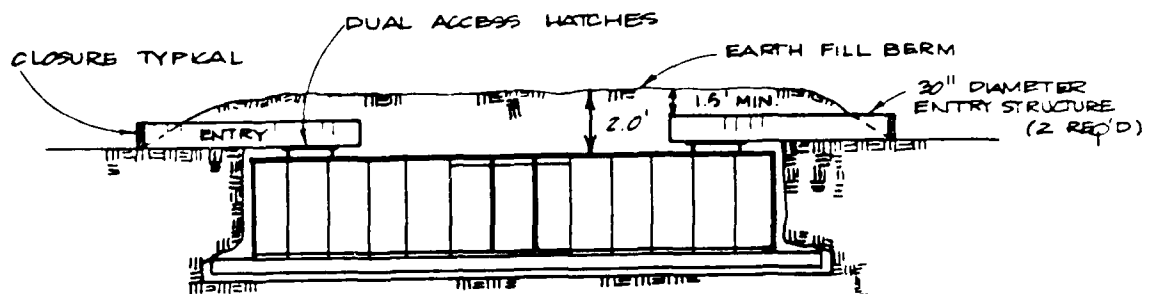


Figure A-2. Typical Buried Refrigerator or Box Car.

Notes:

- (1) Railcar undercarriage and miscellaneous frame components to be removed prior to burial.
- (2) Access to hatches to be fabricated of 30-inch metal pipe or wood framed. Double entry to compartment hatches for ventilation is recommended. Alternate entry may be provided through side of car.
- (3) Entrance closures are required for radiation protection (Figs. A-16 to A-21).
- (4) Cars are to be cleaned prior to burial.

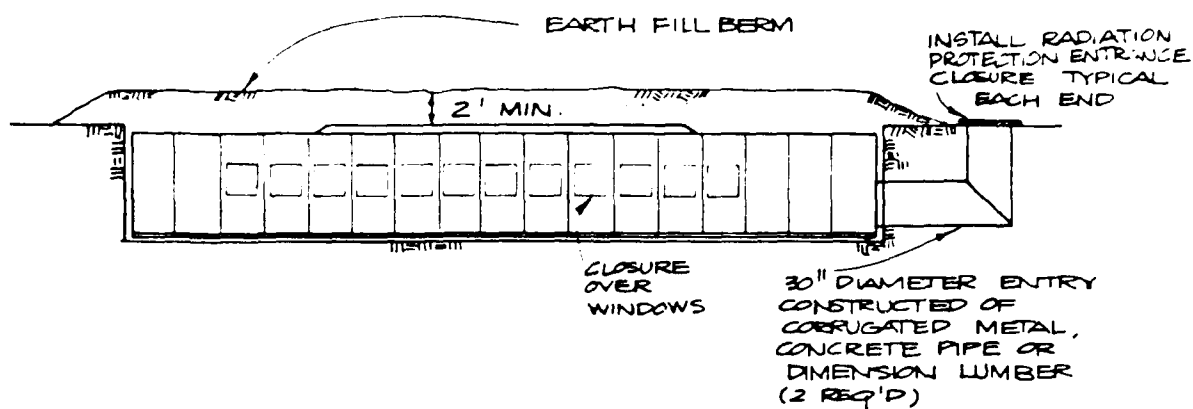


Figure A-3. Typical Buried Passenger Car or Caboose.

Notes:

- (1) Railcar undercarriage and miscellaneous frame components are removed prior to burial.
- (2) All windows must be provided with closures, although ventilation may be expedited by modifying window space.
- (3) Access is proposed through existing doorways at end of car.
- (4) Entrance closures are required for radiation protection (Figs. A-16 to A-21)
- (5) Car interior to be upgraded with post and beam shoring (Fig. A-10)

EXPEDIENT SHELTER FACT SHEET

STORM DRAINAGE SYSTEMS

Major storm drainage facilities and their components can provide long-term shelter in host areas. Two components of a typical system are analyzed for shelter purposes:

- o Storm drain manholes
- o Major conduits -- 5 foot diameter and larger

Limitations

- (1) Manholes should be a minimum of 4 feet in diameter and 6 feet deep (see Figure A-4).
- (2) Manholes are often located in street traffic areas and therefore, may not always be available for shelters. Manholes located in street medians, parking, or non-traffic areas are more accessible.
- (3) Storm drainage conduits may have considerable depth of flow or be located in areas subject to tidal action, thus eliminating their availability.
- (4) Large closures may be necessary at conduit ends to eliminate blast effects. (Two psi won't endanger occupants directly, but can shatter glass). These closures should be measured, and all material prefabricated prior to the crisis period in order to install them within the 72-hour time frame (see Figure A-5).
- (5) Blast effects must be eliminated at all open drain inlets adjacent to the shelter locations. This can be accomplished by sandbagging.
- (6) Depth of water flow may necessitate construction of false floor systems. (See sketch of box culvert type of floor system in Fig. A-6.)

Advantages of Using Storm Drain System Components as Expedient Shelters

Manholes:

- (1) Storm drain manholes are numerous. On any major drainage system they are located from 500 to 1,000 feet apart.
- (2) They require no internal upgrading and are easily adapted to use as one-man shelters, with construction of a temporary wood floor and modifications to manhole lid and closures (see Figure A-4).
- (3) Ventilation equipment is not required, since air movement occurs through drain pipes at base of manhole.
- (4) Manholes as shown in Figure A-4 allow easy access to the major storm drainage system, and thus require less effort to provide entry systems than other expedient shelter types.

Drainage Conduit Systems Greater than 5 feet in Diameter:

- (1) Radiation or fallout shielding is generally not necessary because of depth of burial.
- (2) Ventilation equipment is not needed, as the drainage systems provide natural ventilation at all inlet and outlet locations. Fabrication of radiation and blast resistant closures at inlets and blast resistant closures at outlets must be implemented.
- (3) Drain systems are often long enough to provide shelter for more than one industry.

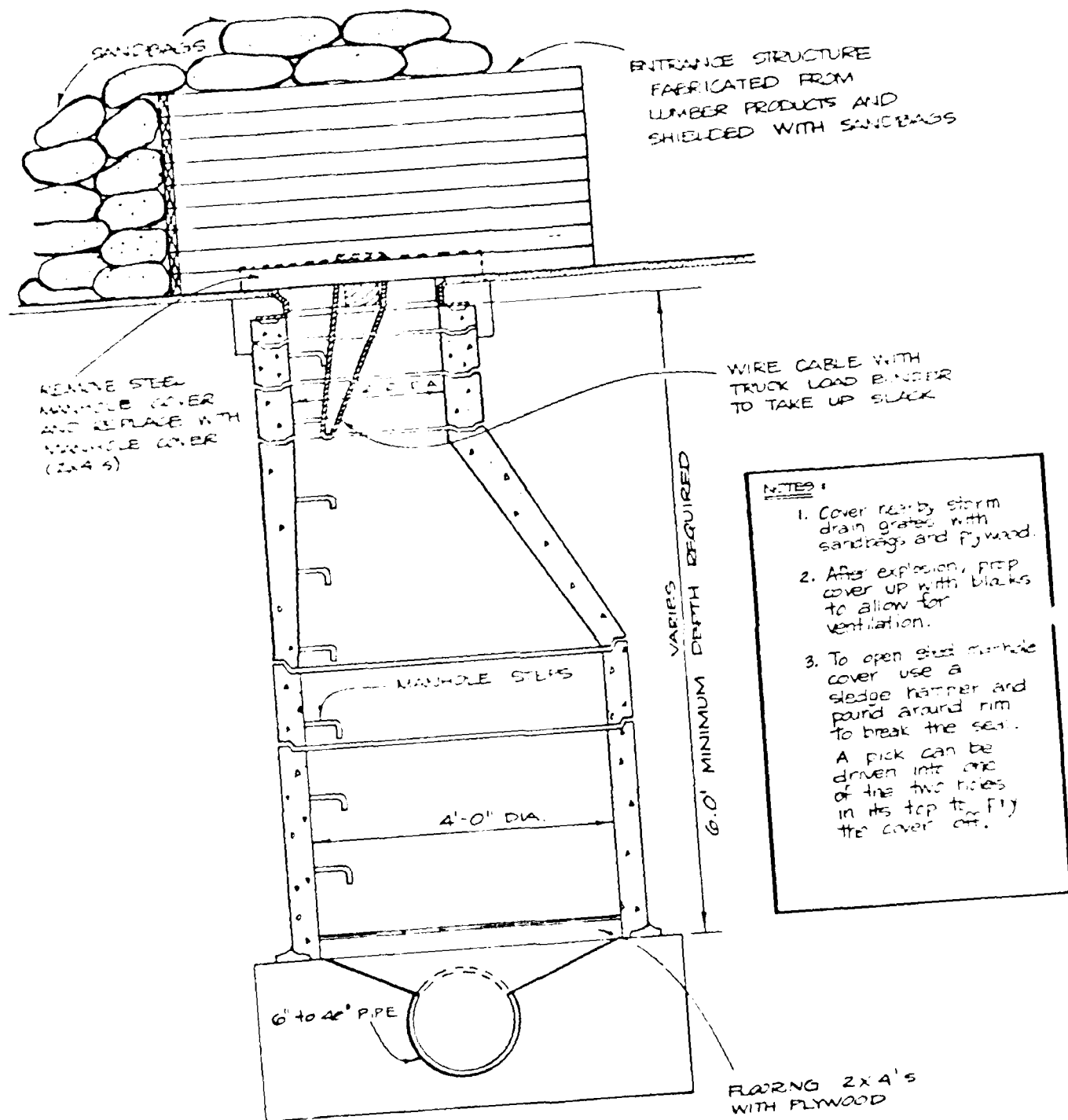


Fig. A-4. Host Area Shelter in Storm Manhole.

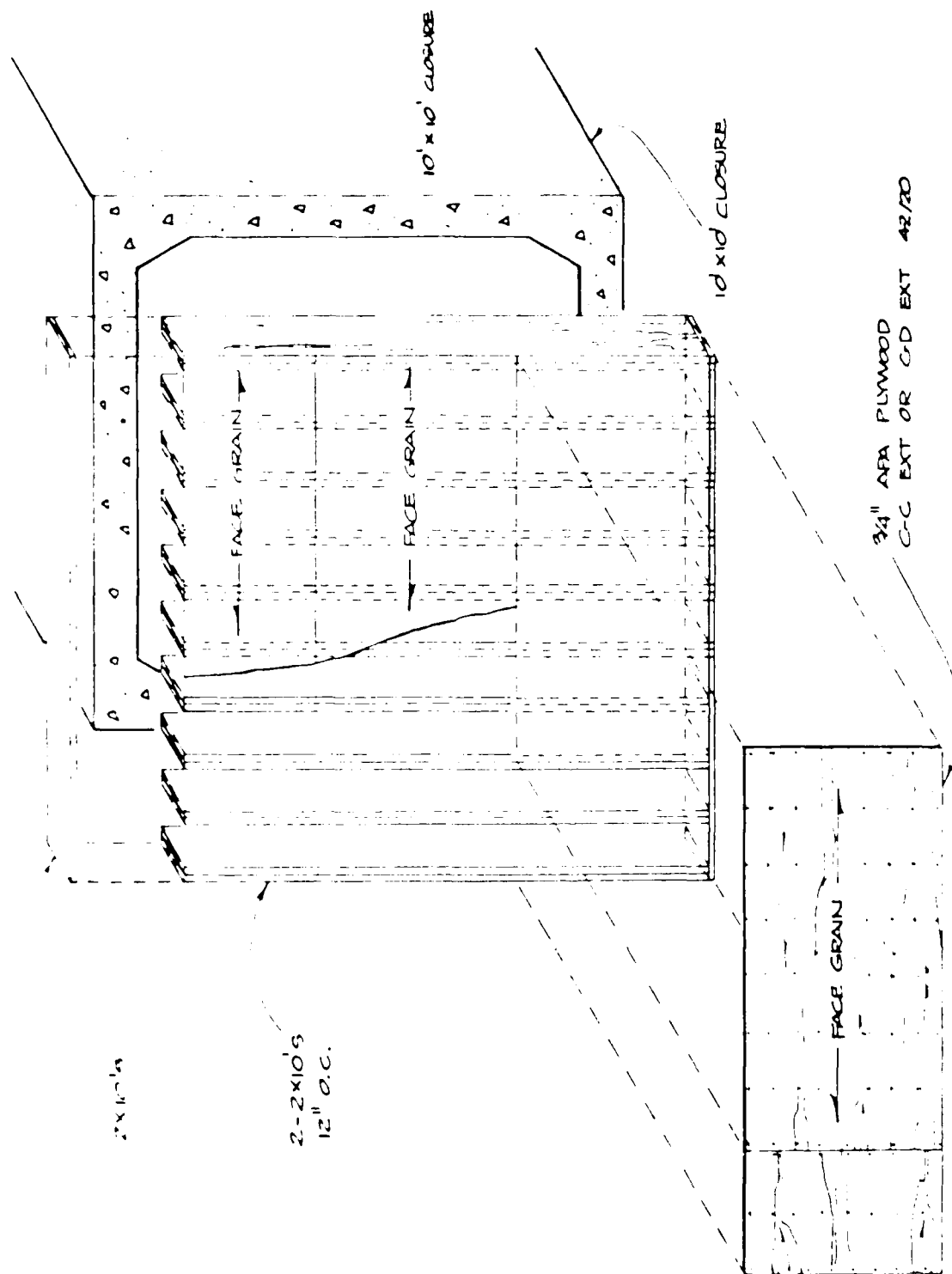


Fig. A-5. Typical Closure for a 10 ft by 10 ft Box Culvert for 2 psi Blast Overpressure.

AD-A102 631 SCIENTIFIC SERVICE INC REDWOOD CITY CA
INDUSTRIAL PROTECTION MANUAL.(U)

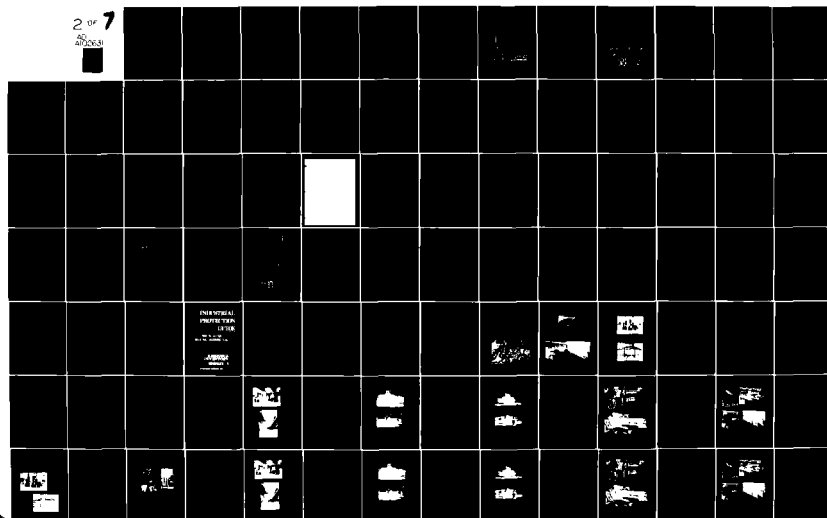
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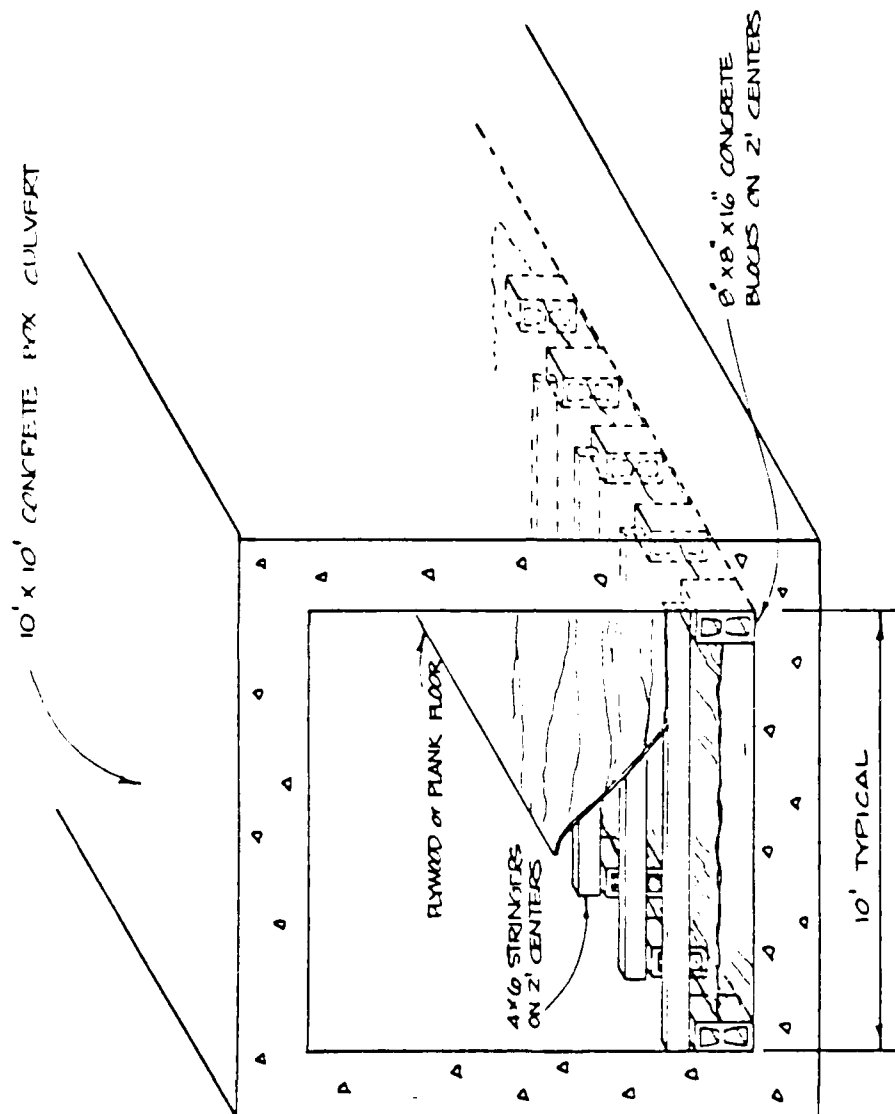


Fig. A-6. Box Culvert Host Area Shelter With Low-Flow False Floor.

EXPEDIENT SHELTER FACT SHEET
CONCRETE UTILITY VAULTS

Adapting prefabricated underground utility vaults (the types used by telephone and electrical utilities) for Host Area shelters is recommended as a practical and easily implemented shelter option. The use of precast utility vault components for a shelter has been previously tested, and placement of a six-man vault and entrance structure, including earth cover radiation protection, required less than 10 hours using three men and heavy equipment.

Figures A-7 and A-8 show the burial of a utility vault shelter consisting of various components needed to complete a shelter structure.

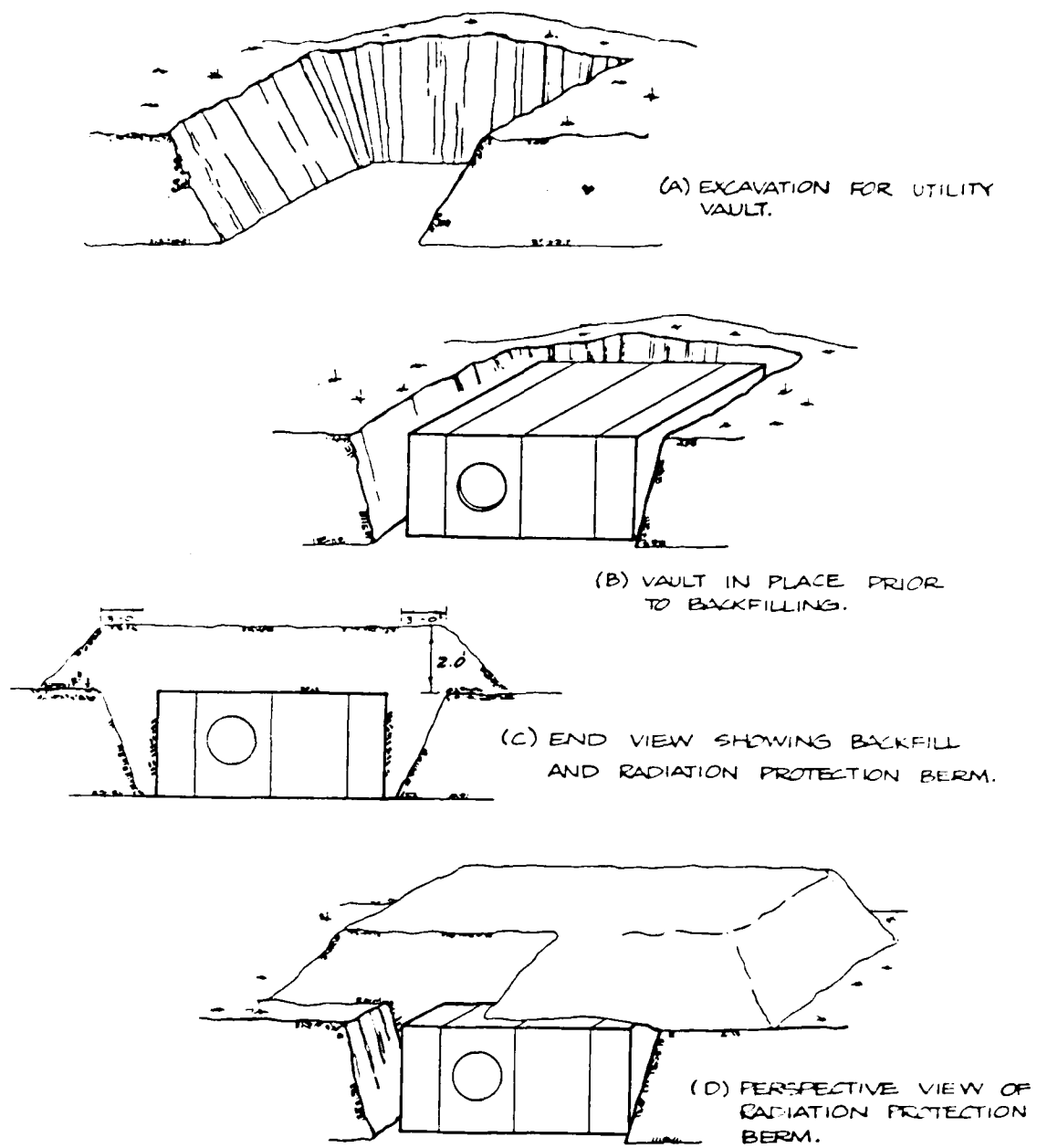


Fig. A-7. Utility Vault Shelter.

ASSEMBLY DRAWING

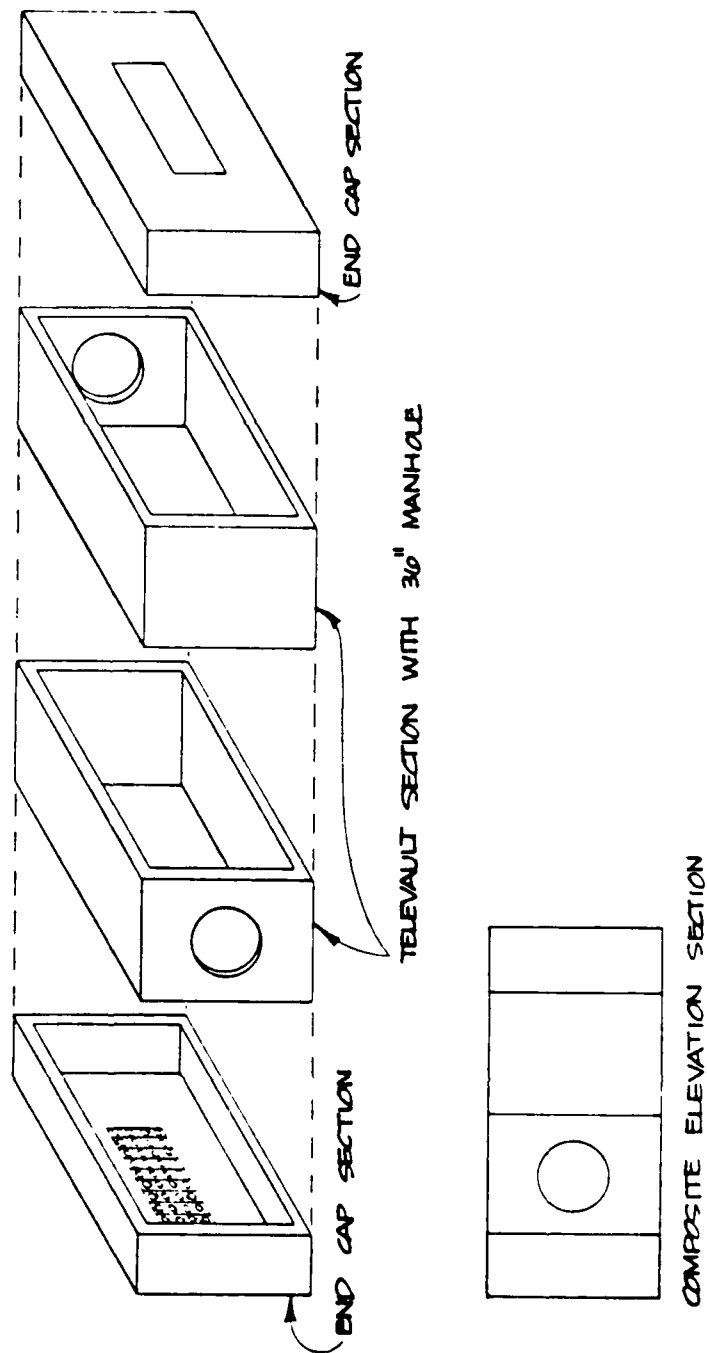


Fig. A-8. Utility Vault Shelter Components, Depicting Upgrading Methods to Provide 2 psi Overpressure Protection.

EXPEDIENT SHELTER FACT SHEET

SHIPPING CONTAINERS

Maritime shipping containers are an easily adapted option to Host Area shelter use. A wide range of container sizes and construction types are available.

Advantages of Using Maritime Shipping Containers for Shelter Purposes

- o A wide variety of standard sizes are available:

Height	Width	Length
8'	8'	20'
8'	8'	40'
8'	8'6"	35'
8'	8'6"	40'

- o Construction materials are steel, stainless steel, glass fiber reinforced plywood (FRP), and aluminum. Nearly all are painted. Containers are generally designed for dry freight and some are insulated. Refrigerator units amount to approximately 7% of the total number manufactured. Typical containers are shown in Figure A-9.
- o The maritime industry has standardized construction details and lifting methods. Certification is required prior to approval for use. Component strengths are listed below.

Container Component	Design Strength, psi
Roof	0.5 +
Floor	26.0 ±
Endwall	1.7 ±
Sidewall	0.9 ±

These strengths reflect only the component listed. Frame members are designed to be stacked fully loaded, nine containers high. The

frame members provide all exterior lifting strength, and thus would provide additional strength.

- o The majority of containers are designed to be waterproof.
- o Upgrading to 2 psi overpressure and radiation protection of 2 feet or more of earth can be provided with post and beam shoring (see Figure A-10). After nuclear blast effects are no longer a threat, the intermediate post shores may be removed.
- o Containers are readily available from manufacturers, repair companies, and firms that deal exclusively in surplus containers.
- o Containers are designed to be adapted to a variety of cargo handling and lift equipment. Empty 20-foot containers weigh approximately 4,300 lb, 40-foot containers, 7,500 lb. (Figures A-11 and A-12).
- o Prior to the crises envisioned in a nuclear war, the containers may be used for secure locked storage of shelter resources and supplies.
- o Containers are easily transported to the site by truck and trailer.

Limitations:

- o The containers are available at nearly every major port facility, but not nationwide.
- o Demand for used containers is high, because of their storage capabilities and versatility.

Maritime shipping containers when properly implemented could be a valuable option to provide shelter. The inherent structural strength of the floor systems indicate containers may possibly survive blast pressures in excess of 20 psi if buried upside down with proper shoring. Full-scale field tests are recommended to determine ultimate capability.

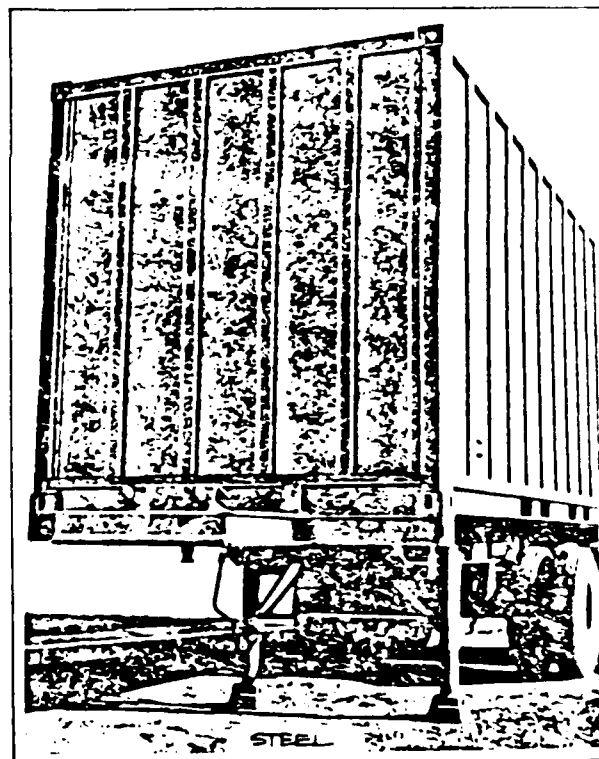
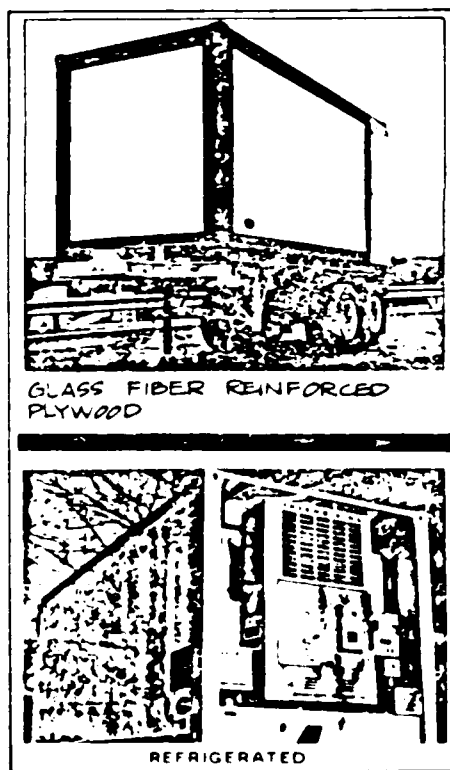
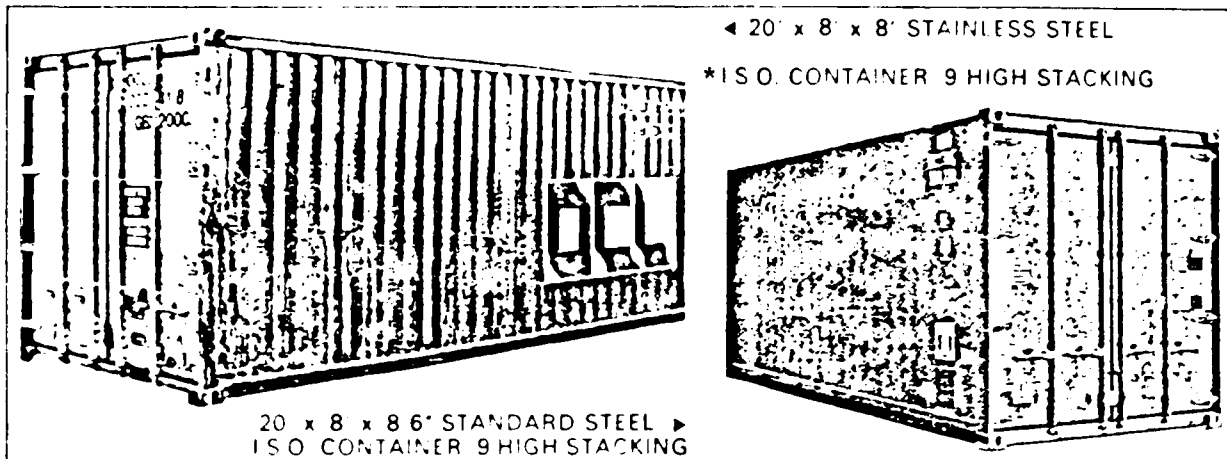


Fig. A-9. Typical Maritime Shipping Containers.

* International Standards Organization.

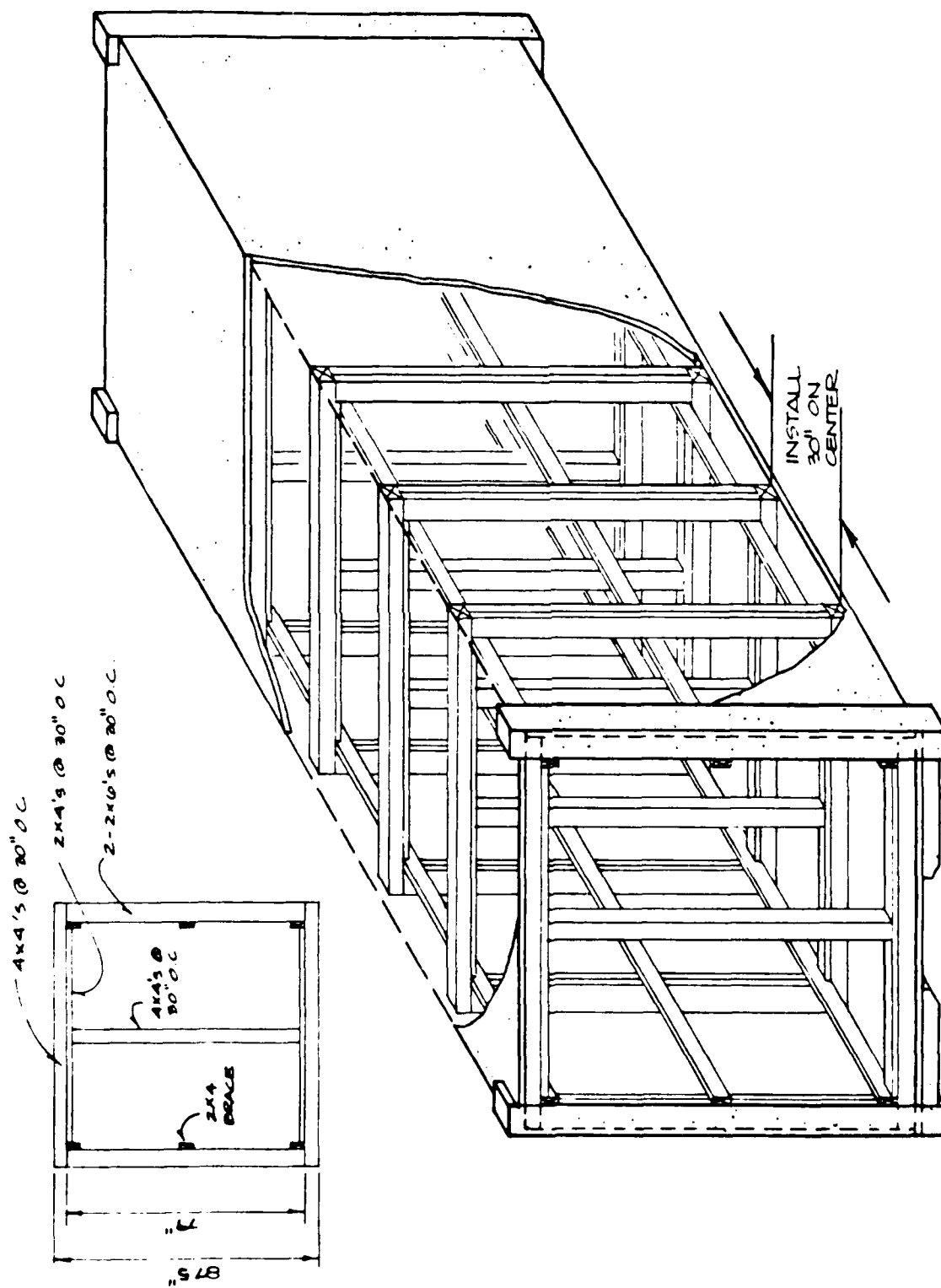


Fig. A-10. Post and Beam Shoring of Maritime Shipping Containers, Railcars, and Truck Van Bodies.

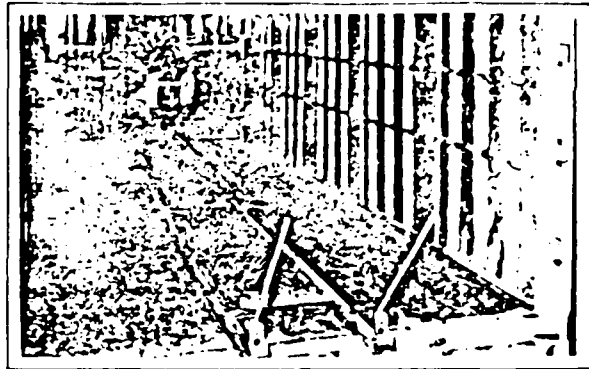


Fig. A-11. Typical Interior Details.

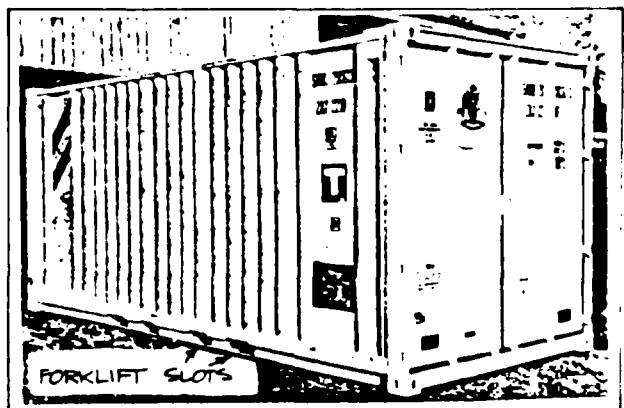
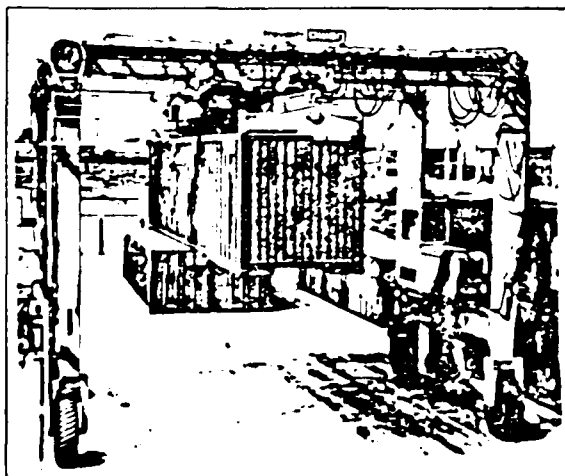
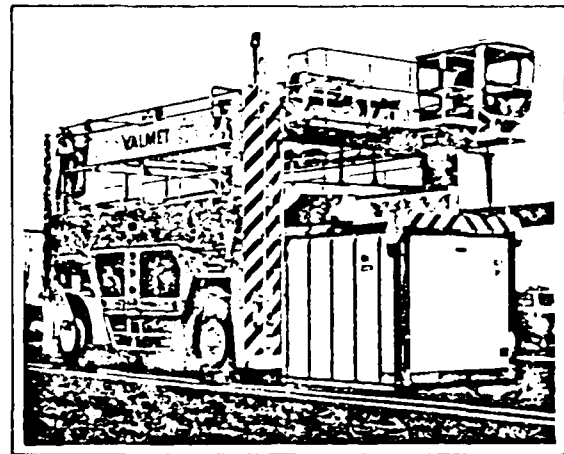
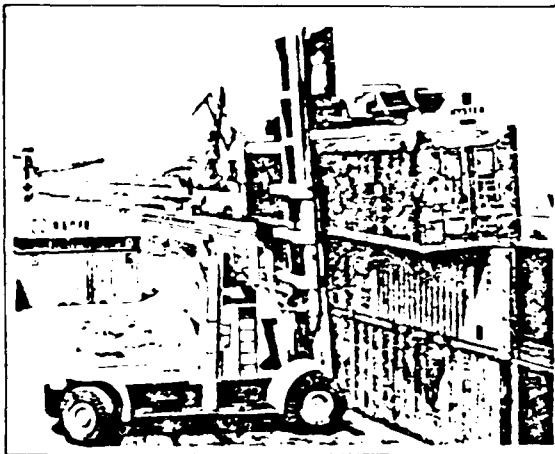


Fig. A-12. Typical Lifting Methods.

EXPEDIENT SHELTER FACT SHEET

TRUCK VAN BODIES

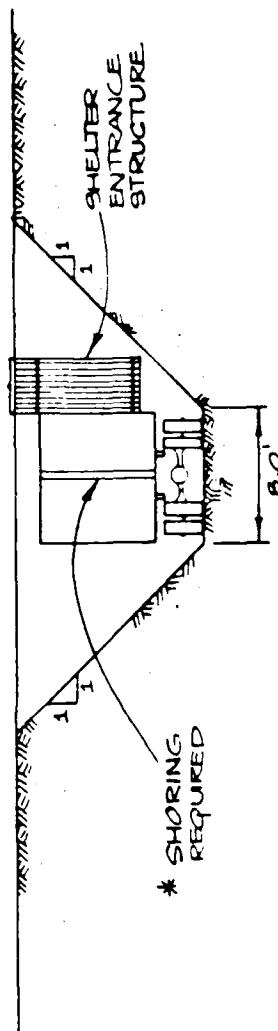
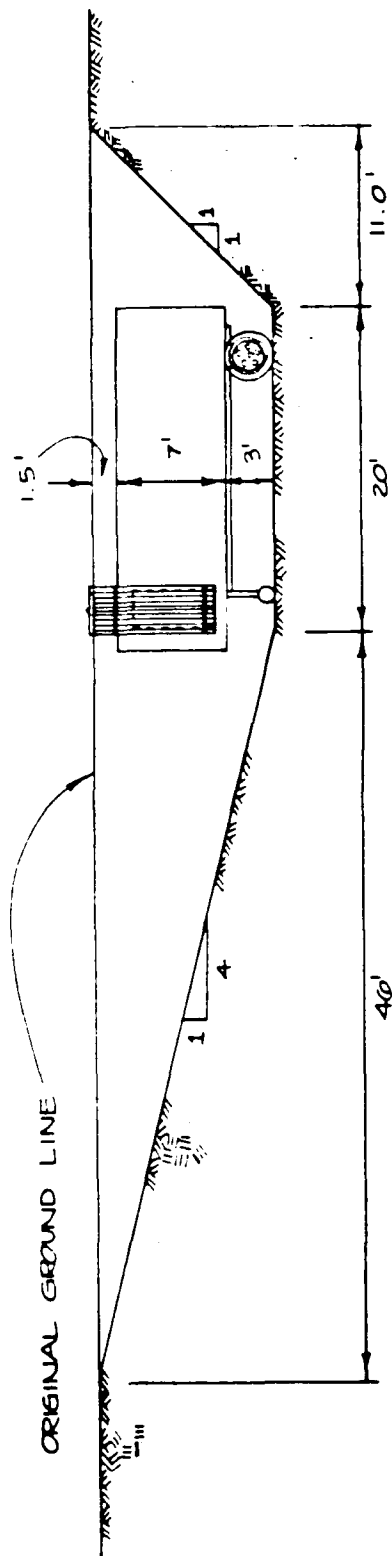
Another resource option for Host Area shelters are truck van bodies (see Figure A-13). Construction types and design capabilities are similar to maritime shipping containers.

Advantages of Using Truck Van Bodies for Host Area Shelter Purposes:

- o A wide variety of sizes are available. They are designed for a variety of uses.
- o Construction materials are steel, stainless steel, and aluminum.
- o They are waterproof.
- o With post and beam construction (Figure A-10), these units can be upgraded to 2 psi overpressure and provided with earth cover radiation protection.
- o They are readily available throughout the United States.
- o They are integral with trailer frame and chassis, ready to be moved.
- o They may be used for secure locked storage for shelter supplies and resources.

Limitations to Truck Van Bodies as Host Area Shelters:

- o They are constructed integral with trailer frame and wheels, and thus reduce the inventory of available transportation resources in the crisis period.
- o Without the trailer frame, structural integrity is eliminated. Thus, they would require significant effort and resources to re-establish equivalent capability as a shelter option.
- o Demand for trailer van bodies is high, and they consequently would be a more costly alternative to other options.



* POST AND BEAM UPGRADES
MAY BE INSTALLED LATERALLY

Fig. A-13. Buried Truck Trailer Van, Host Area Shelter.

TABLE A-4: EXPEDIENT HOST AREA SHELTER PREPARATION TIME

EXPEDIENT SHELTER OPTION	UNDERGROUND BURIAL	ACCESS/VENTILATION FLOOR CONSTRUCTION	SHELTER SUPPLIES
RAILROAD CARS			
REFRIGERATOR	3 MEN, 16 HRS	3 MEN, 24 HRS	2 MEN, 10 HRS
BOX CARS	3 MEN, 16 HRS	3 MEN, 30 HRS	2 MEN, 10 HRS
CABOOSE	3 MEN, 12 HRS + (UPGRADING) 2 MEN, 20 HRS	3 MEN, 20 HRS	2 MEN, 10 HRS
PASSENGER CARS	4 MEN, 20 HRS + (UPGRADING) 3 MEN, 8 HRS	3 MEN, 30 HRS	3 MEN, 10 HRS
STORM DRAINAGE FACILITIES			
MANHOLES	N/A	1 MAN, 8 HRS	1 MAN, 8 HRS
LARGE PIPES	(CLOSURES) 4 MEN, 20 HRS	4 MEN, 24 HRS	2 MEN, 10 HRS
BOX CULVERTS	(CLOSURES) 4 MEN, 30 HRS	4 MEN, 30 HRS	2 MEN, 10 HRS
MARITIME SHIPPING CONTAINERS	3 MEN, 12 HRS + (UPGRADING) 2 MEN, 8 HRS	3 MEN, 20 HRS	2 MEN, 10 HRS
CONCRETE UTILITY VAULTS	3 MEN, 10 HRS	3 MEN 10 HRS	2 MEN, 10 HRS
TRAILER TRUCK VAN BODIES	3 MEN, 10 HRS + (UPGRADING) 2 MEN, 8 HRS	3 MEN, 10 HRS	2 MEN, 10 HRS

EXPEDIENT SHELTER FACT SHEET

OTHER OPTIONS

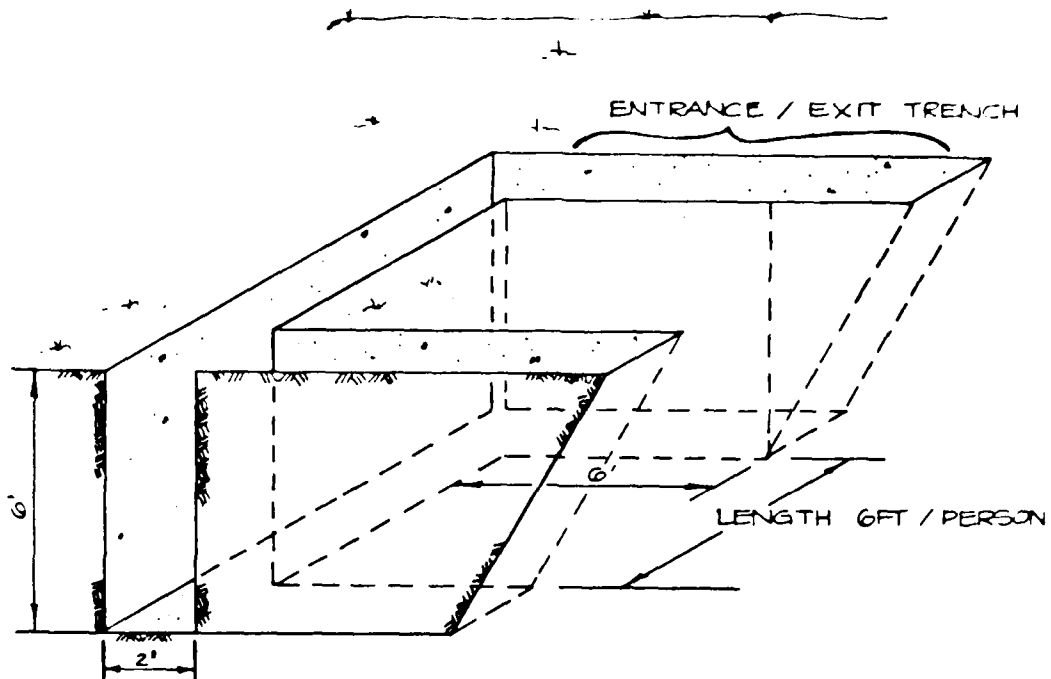
There are a number of other options to provide Host Area shelters. These options may not be the most desirable for long stay-times, but they do provide adequate radiation protection.

Trench Shelters

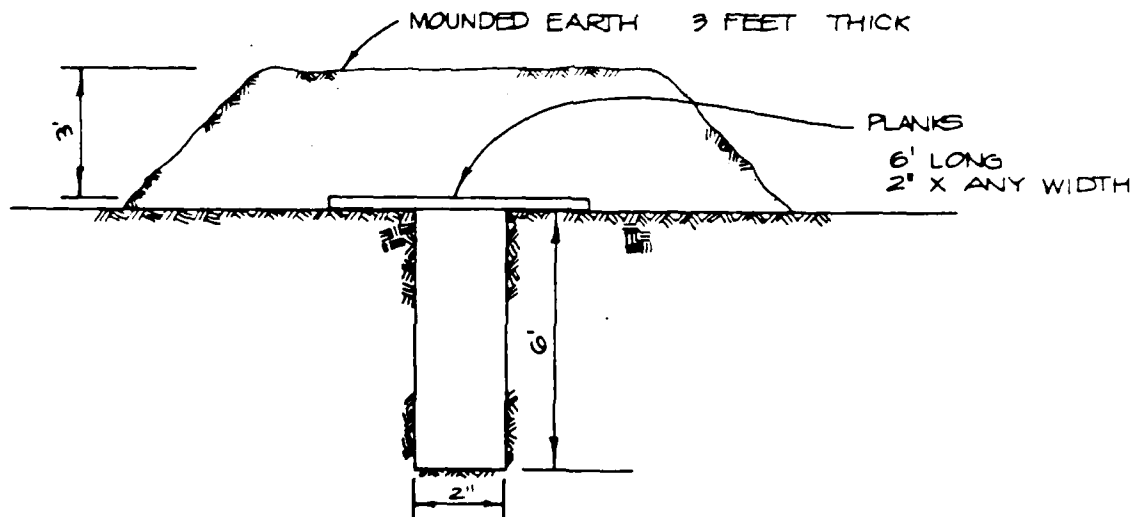
Figure A-14 describes a typical trench shelter. Implementation requires only mechanical excavation equipment, sufficient planks or other resources for support of the mounded earth, and soil strata that will stand vertical to a depth of 6 feet with no ground water at that excavation depth.

Fabricated Manholes

Figure A-15 describes in some detail a shelter fabricated from readily available reinforced concrete and corrugated metal pipe. The construction of such a shelter requires only a backhoe for excavation and backfill. The expedient manhole cover should have an entrance structure similar to the one shown in Figure A-16 including sandbag radiation protection.



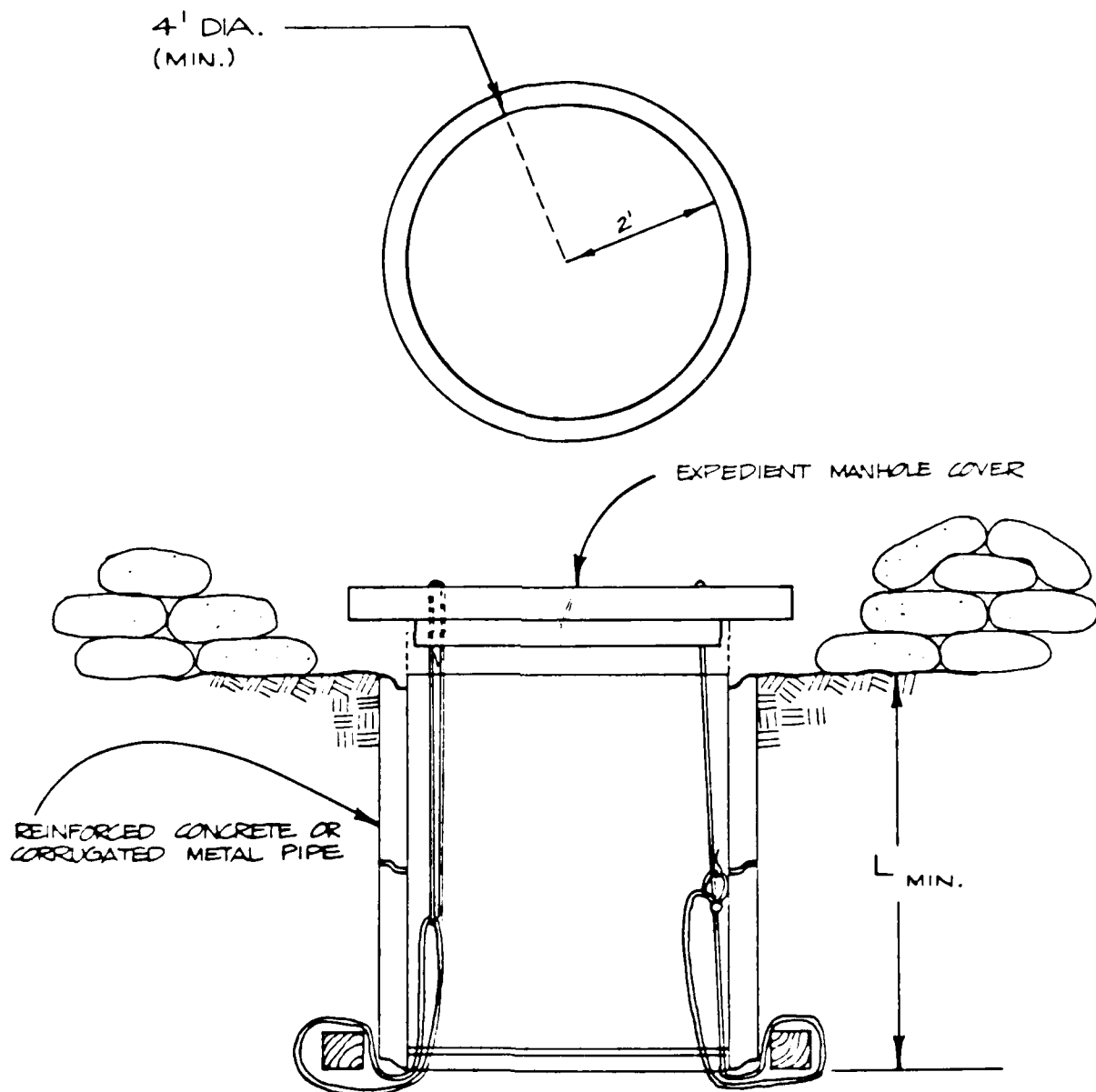
TRENCH SHELTER PRIOR TO PLACING PLANKS AND MOUNDED EARTH



SIZE TRENCH FOR NO. OF PEOPLE - 6 LIN. FEET / PERSON

- NOTES:
1. Place planks.
 2. Place newspaper, plastic sheets, etc. to keep dirt from falling through cracks.
 3. Place 3 ft. of dirt over planks.

Fig. A-14. Expedient Host Area Trench Shelter.



4' DIA. - 1 MAN SHELTER ($L_{MIN} = 6'-0"$)
 5' DIA. - 2 MAN SHELTER ($L_{MIN} = 7'-0"$)
 6' DIA. - 3 MAN SHELTER ($L_{MIN} = 7'-0"$)

7' DIA. - 4 MAN SHELTER ($L_{MIN} = 7'-0"$)
 8' DIA. - 5 MAN SHELTER ($L_{MIN} = 6'-6"$)

Fig. A-15. Fabricated Manhole-Like Shelter.

CLOSURE AND ENTRY ALTERNATIVES FOR UNDERGROUND SHELTERS

The development of 2 psi blast resistant and radiation protected Host Area shelter space requires that consideration be given to shelter entry structures. In cases where existing basement areas are to be upgraded, shelter entry is not a significant problem; instead, providing closures for existing openings must be considered. A radiation protected entrance to all below ground entries is shown as Figure A-16.

Shelter Entry Structures

Expedient shelters require fabrication of novel entry structures including efficient use of available resources. A typical wood construction vertical entry structure is shown in Figure A-17 and suitable closure is shown in Figure A-18.

As an alternative to wood construction, concrete pipe or corrugated metal pipe entry structures may be used. Figure A-19 shows such a structure, and Figure A-20 is a suitable closure for a circular entry structure.

A combination wood construction drop entry and pipe construction horizontal entry structure is shown as Figure A-21. This figure provides details using alternative combinations of available materials.

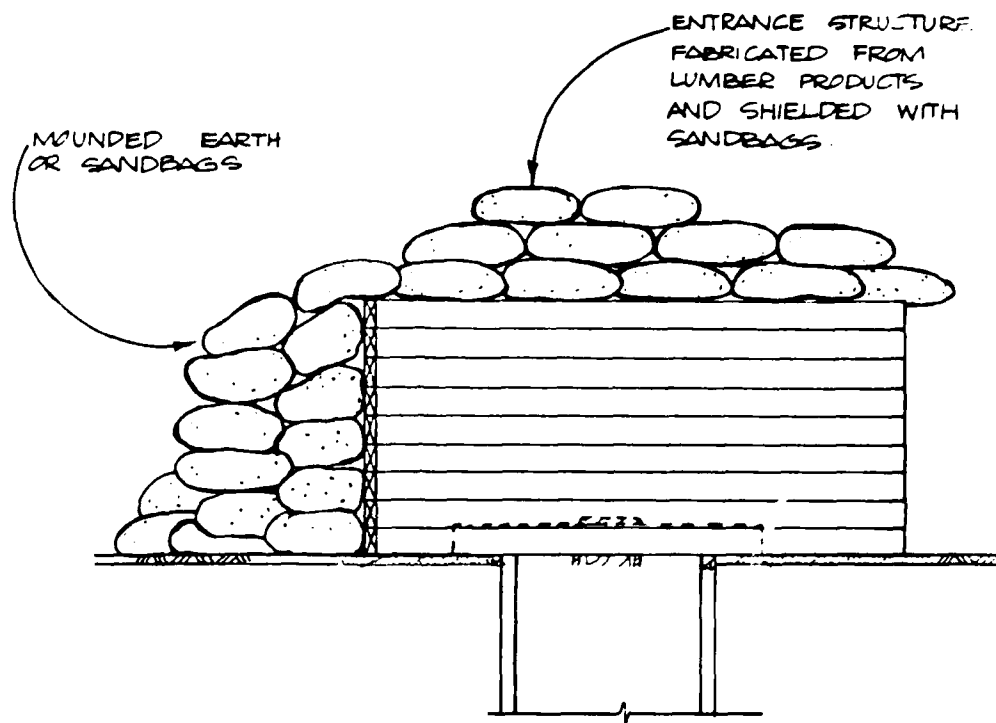


Fig. A-16. Radiation Protected Entrance Structure to All Below Ground Shelters.

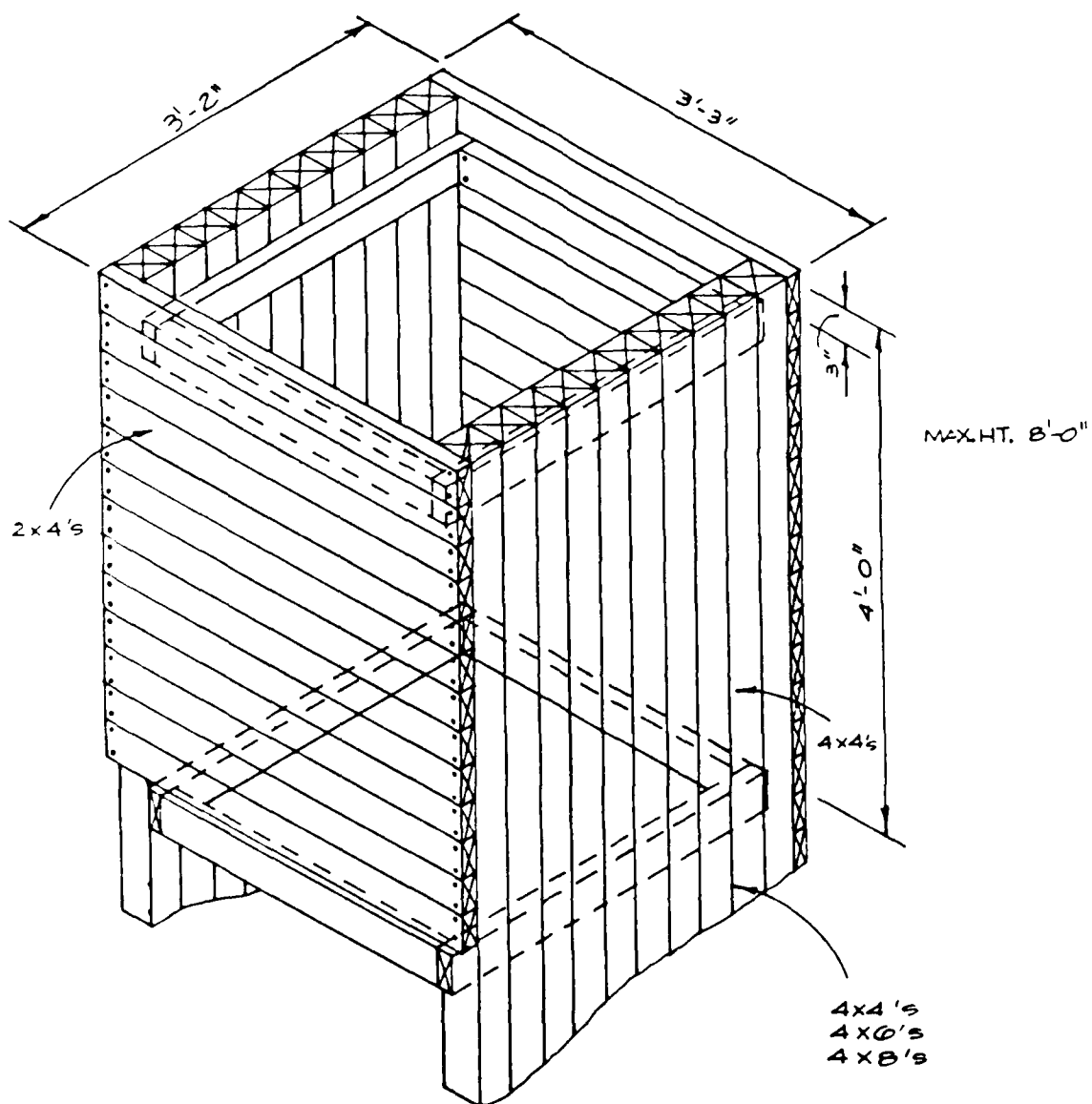


Fig. A-17. Host Area Shelter Entrance.

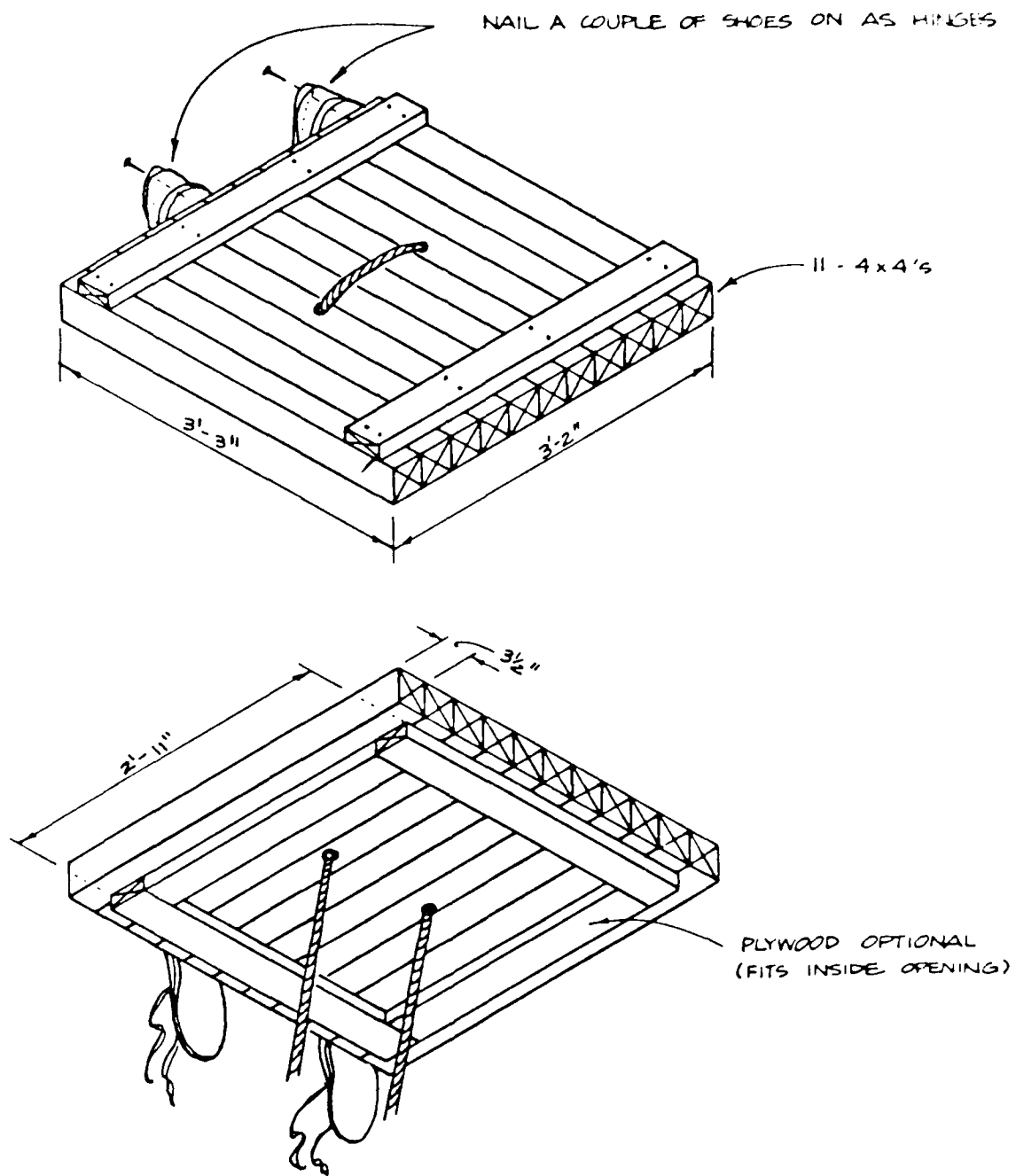


Fig. A-18. Host Area Shelter Door.

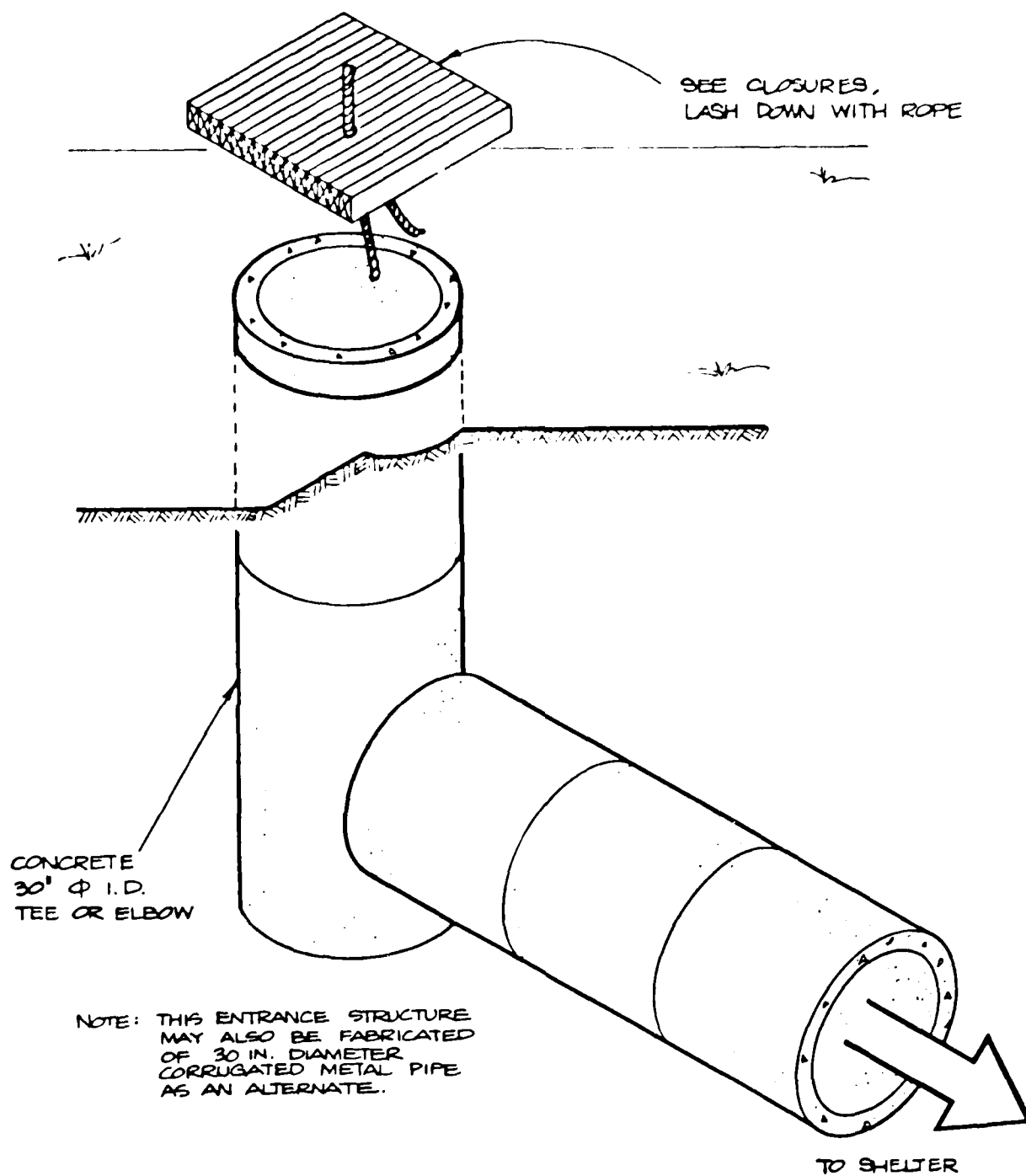


Fig. A-19. Entrance To Shelter.

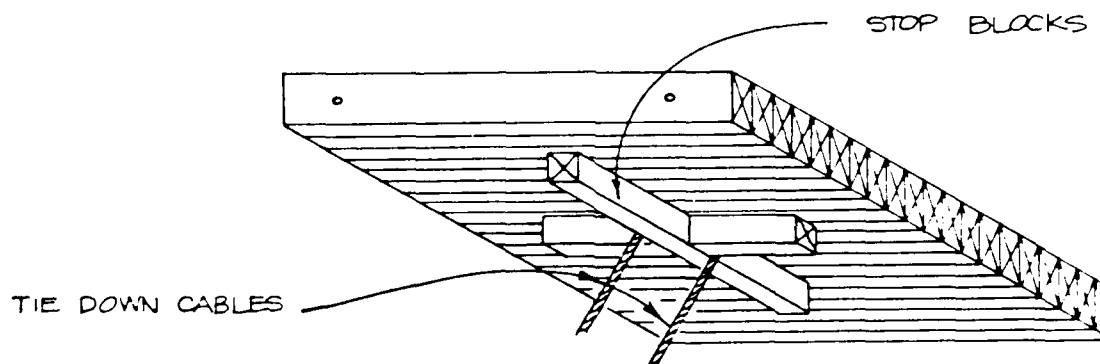
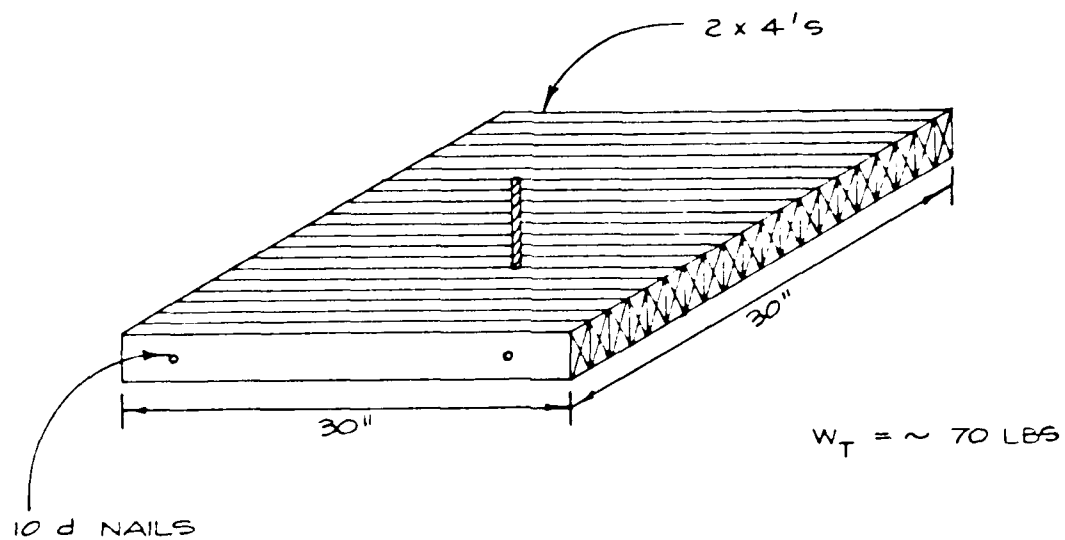


Fig. A-20. Expedient Manhole Closure, Host Area.

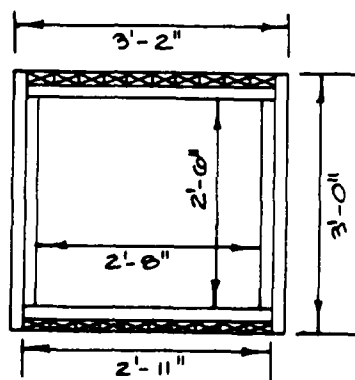
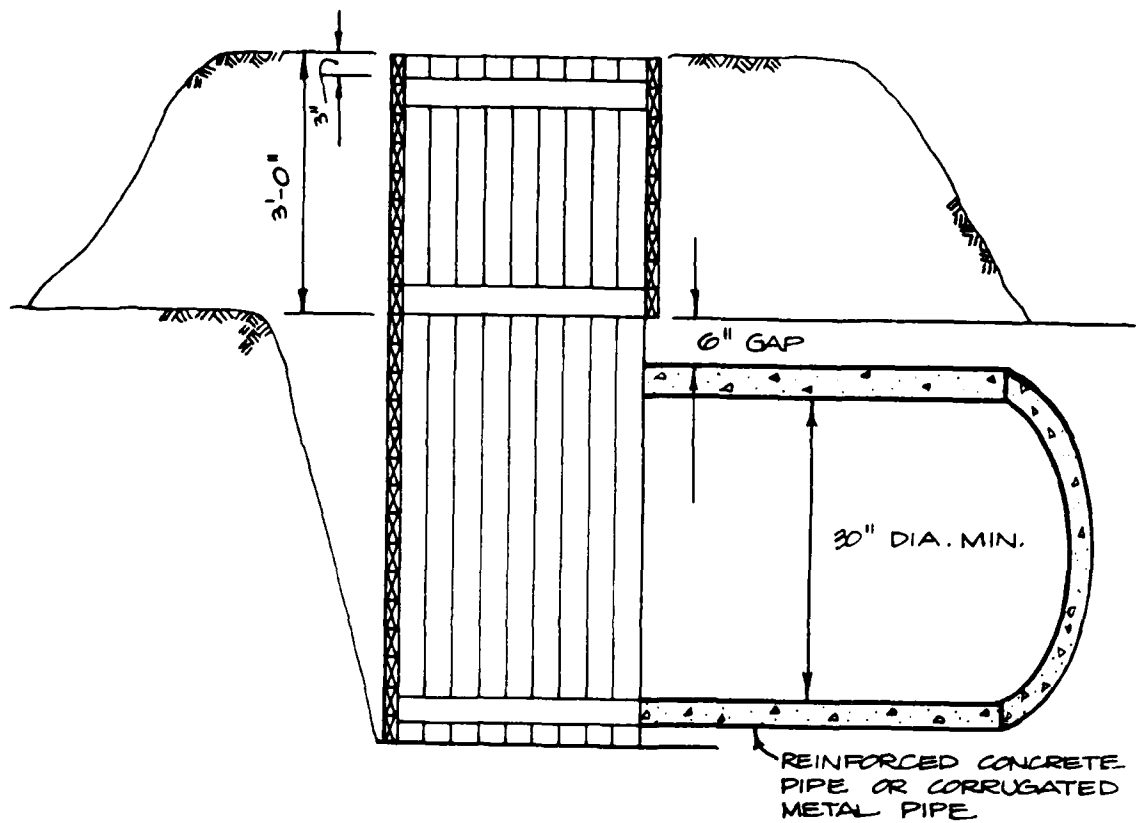


Fig. A-21. Typical Entryway to Buried Shelter With Culvert Shown.

APPENDIX B

**SHELTER MANAGEMENT
PERSONNEL RECOVERY
BIBLIOGRAPHY**

SHELTER MANAGEMENT

The civil defense preparedness effort is based on implementation of a national network of shelters, of which Host Area shelters are a major part.

Under nuclear attack crisis conditions, the responsibility of a shelter manager is significant. Access to outside support will be minimal and perhaps non-existent for some time. The sheltered employees and their families will be living under severely crowded conditions, movement will be limited, resources will be limited to supplies and equipment in the facility, and their anxiety levels will be high.

A Host Area shelter must be self-reliant

A Host Area shelter may be closed off from the rest of the community for a period as long as 14 days. The supplies, services, and professional skills available will be contained within the facility and among the shelterees. Shelter life is a severe physical, mental, and emotional demand upon the manager's leadership; upon the staff he designates; and upon all members of the sheltered population.

Managing a Host Area shelter combines skills in operating a hotel, industrial plant, and leading people in an emergency. In addition, the shelter manager is responsible for ventilation, fire protection, and the following functions:

- Registration of occupants
- Assignment of space
- Rules and regulations of occupancy
- Selection and assignment of assistants (delegate authority as required)
- Security and safety of occupants
- Morale, including religious, psychological counseling, and recreation activities
- Obtaining and disseminating national and local information
- Attention to social service requirements
- Logistical requirements
- Assuring facilities for personal hygiene
- Maintaining adequate sanitation

Providing for the comfort of occupants
Health services
Security for valuable personal possessions
Disposition of the dead
Continued upgrading/improving shelter, and expedient shelter construction
Radiological protection
Atmosphere control

Host Area shelters are to be stocked with supplies and equipment (food and water, medical and sanitation kits, packed ventilation kits, radiation survey meters, dosimeters with which to measure doses of radiation). If the shelter is not stocked the manager must acquire needed materials.

Here are the most urgent requirements:

Water
Food
Emergency ventilation equipment
Emergency lighting equipment
Hand radios
Shovels, hand tools, nails
Basic medical supplies
Sanitation equipment
Administrative materials
Recreational materials
Essential toilet articles

The average living space per person will be only 10 square feet. Living conditions will be somewhat austere. Facilities and procedures for personal hygiene, sanitation, medical attention, and recreation will be severely limited.

The Host Area Shelter Manager

As Host Area shelter manager you must give special attention to:

(1) **Radiological Defense.** People can protect themselves against fallout radiation, and have a good chance of surviving, by removing themselves as far as possible from the fallout particles outside. In addition to protecting people from fallout, most shelters would also provide some limited protection against the blast and heat effects of nuclear explosions that were not close by. Basement shelters better protect persons inside from absorbing many of the gamma rays given off by fallout particles outside.

(2) **Ventilation.** Shelter populations cannot survive without air. Atmosphere and temperature control are handled by methods of air exchange: introducing fresh air into the shelter and simultaneously removing stale air.

(3) **Communication.** It will be difficult to get information about the outside world. It is the manager's responsibility to see that someone monitors the Emergency Broadcast System on a battery-operated radio at all times. Once a shelter is closed, it is urgent to try to get information on what is happening and to relay it quickly to the population, to promote morale and cooperation, and to avoid rumors and their inherent dangers.

(4) **Morale.** In such a trying ordeal of confinement, maintaining morale is critical. All religious, psychological counseling, and recreational activities must be carried out within the group. The manager must remember the importance of a sense of humor as well as a calm confidence.

A Host Area shelter manager must be prepared to cope with every aspect of the lives of all shelterees on a 24-hour basis.

In a Host Area shelter, the community's established law enforcement procedures will be absent. Further, if there are law enforcement officials present in the shelter, they will still be reporting to the Manager. Therefore, the

Manager is ultimately responsible for maintaining order, and for encouraging and enforcing our society's standards of moral and humane behavior.

The fallout shelter manager functions as an extension of local government within the shelter, supervising shelter operations until organized units of government can resume direction of the community recovery effort. The manager is there to maintain life and return to the post-attack world shelterees who are physically and psychologically able to help in the recovery effort.

Rapid decisions, visible leadership, demonstration of and delegation of authority are vital. The efficiency of shelter operation will ultimately depend on the shelter staff selected by the shelter manager. It is expected that some industry shelters will have in excess of 100 shelterees. Successful management of these numbers of people will be based on how good a staff is selected. The following guidelines are listed for shelter staff selection:

- (1) Choose core management staff
- (2) Choose and instruct team leaders for protective functions
 - a) Fire safety and security
 - b) Communications
 - c) Health and sanitation
 - d) Food and water
 - e) Maintenance and supplies
- (3) Choose a team leader for registration, identification, and assignment of space
- (4) Choose staff or task teams to be responsible for:
 - o Radiological defense
 - o Supply
 - o Technical operations, repair and maintenance
 - o Medical
 - o Fire
 - o Safety and rescue
 - o Communications
 - o Administration

- o Water
- o Food
- o Sanitation
- o Security
- o Night watch
- o Psychological first aid
- o Training and education
- o Support and special services
- o Exercise, recreation, and religion

(5) Staff selections are needed for:

- o Organizing the shelter population into community groupings
- o Developing a floor plan for major functions and areas
- o Appointing an advisory committee as liaison between shelterees and manager

PERSONNEL RECOVERY

After a nuclear weapons explosion, industry workers will have approximately one-half hour to find shelter before fallout begins to deposit. Further away, fallout might not begin for an hour or two after the explosion. With preplanning and preparation, most industry workers can use this time to evacuate to the Host Area or to some other prepared shelter location with more supplies and space; however, roads and highways may be covered with litter, and thus impassable by car.

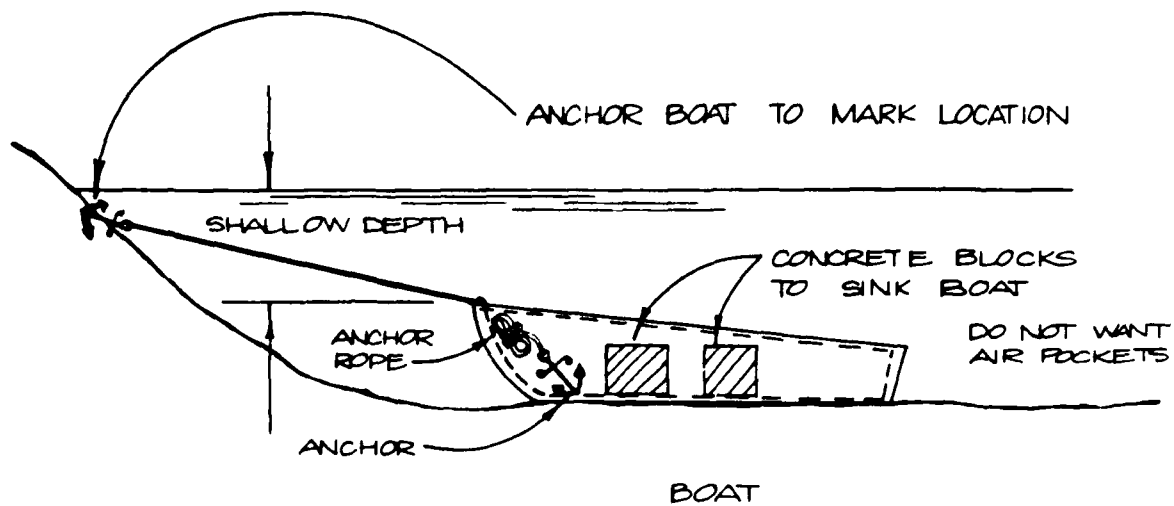
On foot, a man can travel two or three miles in half an hour, but if a bicycle, motorcycle, or four-wheel-drive off-highway vehicle is stored near the industry, the distance traveled after a nuclear burst but prior to the arrival of fallout may be greatly increased. This is somewhat dependent on damage along the route.

In industrial areas there is also a likelihood of numerous secondary fires caused by nuclear weapon damage. These fires could cause an additional latent

hazard to people sheltered in the risk area. Finally, if the explosion occurs during a personnel shift change, overcrowding of the industry shelter is another possibility that would make escape from the risk area desirable. If suitable escape vehicles and routes are provided, key worker personnel will have the flexibility of relocating to the Host Area to take shelter where hazards are generally less. An alternative that may be much preferred over wheeled vehicles for transporting key workers out of the risk area in an emergency is by waterways -- if they are within a mile or two. Waterways are less likely to be blocked or impassable. Figure B-1 shows a method to protect boats from blast damage.

To ensure recovery of personnel from the risk area after the nuclear attack, consideration must be given in advance -- and Host Area support provided. The following criteria should be used to provide for such recovery:

- (1) Plan mutual support between or among shelterees in the risk area to get out of blast shelters and to get where Host Area rescue teams can make pickup.
- (2) Locate the buried shelters accurately with respect to some reference that will be easily identifiable after the attack. Debris from other areas may obscure or cover the shelter entrance.
- (3) Strategic location of individual transportation -- motorcycles or other vehicles as discussed earlier, or if near a large body of water, boats (Figure B-1). These should be left in the risk area. Larger transportation vehicles should be made ready in the Host Area for rescue with a few individual scout vehicles to assess access routes.



STORE IN SHELTER:

1. BAILING BUCKETS AND SPONGES FOR WASH DOWN
2. LIFE JACKETS
3. OARS AND MOTOR (STORE GAS OUTSIDE SHELTER IN HARDENED HOLE)
4. TARP BOAT COVER

SINK BOAT IN CHEST DEEP WATER SO THAT CONCRETE BLOCKS CAN BE TAKEN OUT AND BOAT REFLOATED.

Fig. B-1. Preparation and Protection of Boat for Escape Vehicle.

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For more information on certain aspects of shelter options, the following references may be consulted:

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CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 4

PROTECTIVE HOUSEKEEPING

This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

Booklet 4
PROTECTIVE HOUSEKEEPING

Coordinator: _____
(name)

Alternate: _____
(name)

Objective: To reduce the hazards caused by secondary effects of disasters by taking action to prevent or reduce the number of opportunities for secondary effects to happen.

This booklet is part of a plan to protect industrial plant equipment from possible damage in event of a major disaster. It develops an approach for implementing protective housekeeping that can reduce the severity of earthquake, hurricane, tornado, and weapons effect damage to equipment left onsite. Fires are a major destructive force in such large-scale disasters, so onsite combustible materials must be removed or neutralized. To reduce hazards from toxic and hazardous materials during recovery, containers must be protected from rupture or puncture. To reduce damage from electromagnetic pulses, all electrical systems not deliberately functioning must be unplugged from power lines, and antennas disconnected. To reduce puncture and other damage from missiles created by wind forces, loose materials, debris, containers, and vehicles must be relocated (tied down, evacuated, buried).

INFORMATION FOR COORDINATORS

Disasters that cause widespread physical damage (earthquakes, hurricanes, explosions) frequently cause ruptures of pipelines, tanks, chemical containers, fuel drums, which contribute to widespread ignition of fires. These fires are a secondary effect of the disaster that can be reduced by good housekeeping practice. Because fire is so often a major cause of property damage in this type of case, good housekeeping practice is very important. It may simply involve cleaning up and organizing flammable and volatile solvents so containers and transfer lines are less likely to rupture, or to catch fire if they do rupture. With a nuclear weapons disaster, there are other secondary effects that can also be reduced by housekeeping activities. The following list summarizes the major ones:

PREVENT SECONDARY EFFECTS --- BY THIS HOUSEKEEPING ACTIVITY

1. Fires

Remove and confine or bury combustibles so they cannot ignite or blow about.

Close fuel valves, disconnect vulnerable fuel lines to prevent line rupture and fuel spillage.

Remove drums, cans, small containers of enclosed combustibles (paints, solvents, etc.) to remote location.

Empty above ground fuel storage in raised tanks into below ground storage or drums (then harden as in Booklet 9).

PREVENT SECONDARY EFFECTS --- BY THIS HOUSEKEEPING ACTIVITY

- | | |
|---|---|
| 2. a) Loose Object Impacts | Relocate useful unanchored items so they can't become airborne missiles in the high velocity winds. (See Figures 1 and 2) |
| | Remove or bury junk and debris. |
| b) Damage or Destruction of Instruments, Controls | Remove and store in a safe location. |
| c) Broken or Ruptured Fuel Lines | Close main valves, disconnect and empty vulnerable fuel lines. |
| d) Hazardous Material Spills | Remove, bury, or harden hazardous materials containers. <u>Do not</u> empty into sewers! Map locations! |
| 3. Electrical and Electronic Equipment Burnout | Disconnect this kind of equipment from incoming power transmission lines, from antennas, and from conducting rails, etc.
Communications industries should install EMP protection. |
| 4. Inaccessibility Due to Deposits of Radioactive Particulates | Clear debris and non-essentials away from gutters, drains, water channels, and around essential work areas, so that radioactive dust can be hosed off more quickly by recovery crews later. |

DEFINITIONS

Combustibles -- Whatever you can ignite using kindling.

Critical Delicate Gauges, Instruments, Controls -- Essential items that would be damaged by flying debris or missiles and which you cannot replace, or repair readily with simple tools.

Vulnerable Fuel Lines -- An exposed (as opposed to buried) section of fuel line or coolant piping that would probably break if hit by flying debris and would spill combustible fluid.

Unanchored Objects That Can Become Flying Missiles -- Gas bottles, stacks or wood and materials, debris boxes, vehicles, etc. Anything that a tornado, or hurricane-like wind could move or lift. (See Figure 1).

INSTRUCTIONS FOR COORDINATOR

The protective housekeeping plan is divided into two parts: Plant Protective Housekeeping is presented first, followed by Office Protective Housekeeping. These activities can be conducted concurrently. Both parts should be read before starting protective housekeeping activities.

Starting on page 13 is a table that identifies over 100 common chemicals that are a serious hazard. The table is divided into 18 subgroups that are compatible enough within a group they can be stored together. But, between groups, chemicals should be separated, because mixtures across groups may explode, combust, boil, and vaporize, or otherwise react to cause additional rupture and spreading. Note, it is particularly important to isolate the toxic materials so that they will not become a problem during recovery. These should be buried in a trench, if possible, covered, marked, and mapped.

PLANT PROTECTIVE HOUSEKEEPING PLAN ELEMENTS

1. Establish collection points (or final storage points)

A A location to collect vulnerable items that require special attention:
(1) Gauges, (2) Delicate instruments, (3) Delicate controls, (4) Other.

B A location to collect useful but unanchored and less vulnerable items that need to be tied down or immobilized: (1) Gas bottles, (2) Disconnected fuel lines (3) Other.

C A location to collect useless junk, combustibles, debris, loose scrap metal, etc., to be disposed of.

D. A location to collect hazardous materials in drums and packages for hardening.

Note: Pick locations that are convenient but that will be out of the way. For example, **A** might best be a truck, for removal to the Host Area, and **B** might be part of a dirt yard area where items could be laid in a ditch or trench to keep them from moving. **C** could be the same, or an unused part of a loading dock if vehicles are available to move such junk to (a) the dump, (b) a ravine, (c) a large ditch. **D** should be an open area, away from structures of any kind, to be hardened as shown in Figure 3. Enough room is needed to ensure adequate space between incompatible groups of chemicals (see Table 1).

2. Organize work and personnel as follows:

A Divide outdoor and indoor plant areas into easily **defined regions** so that tasks can be designated without fear of overlapping effort.

B Designate **work parties** for these regions to conduct protective housekeeping activities.

- C If your plant is too large to supervise the protective housekeeping yourself, you should establish a fixed, central location for your **control center** in order to be readily available at all times.
- D Establish a record keeper for each work party and, if your plant is large, one messenger for each five work parties to maintain records and liaison. Use the Protective Housekeeping Work Party status forms attached.
- E Establish at least one **troubleshooting and followup team** (more, if the plant is large) to help where and when you decide they are needed. Utilize existing personnel familiar with shutdown procedures used in case of fire and/or explosion.
- F Establish a **tool crib** and allocate tools and equipment among work parties. (Be sure to recover tools as teams finish so they will be available for other operations.)

Note: Make up work parties to cover all regions in two hours, if possible. You will need to assign somebody from the plant maintenance crew to each region, to decide what vulnerable items should be disconnected or disassembled and what is to be considered junk. "Red" flags (or equivalent) should be given to work parties to tag any items passed over; e.g., because the operating crew has not yet completed shutdown. This will make it easier for the followup team to spot and take care of later. The "red tag" system will also help identify where tools will be needed again, later.

3. Explain the whole operation to teams before sending them out. Instruct personnel to report back as tasks are completed. Dispatch work parties when instructions are clear.

4. After about 20 minutes, dispatch messenger(s) to get status reports from each work party -- and report back in 10 minutes or less -- as you will need three to five status reports to keep bottlenecks from forming. Send one messenger to

each of the four collection points to report the amount of material accumulated there. Use the Storage/Disposal/Harden Status Report form attached.

5. Use your best troubleshooter(s) to follow up work parties to disconnect electronic and electrical equipment that is non-essential now, (and to red tag any still operating for disconnection later). Request a report back in one hour to provide you with a status report.

6. When first round reports are assembled, complete the status report and communicate the information to the plant Hardening Operations Manager.

7. Reassign work parties that finish their region to additional regions, to augment work parties in incompleated regions, or turn them over for reassignment to other coordinators.

8. Have one of your troubleshooters check that coolants and solvents have been removed from metal cutting machinery, etc., and relocated with the hazardous materials.

9. Maintain operations until all tasks are complete and all red tag items completed. A final followup should be made by the best qualified team you can field to ensure that all possible (practical) steps have been taken to reduce or eliminate secondary hazards.

10. When all tasks are complete, have remaining protective housekeeping teams report to plant control center for assignment or dismissal.

11. Draw a map to show locations of each storage/disposals' site and contents -- to use during recovery. Make a duplicate map of the hazardous materials site location and contents list. File duplicate with the Host Area authorities -- for use in case of emergency to keep recovery crews out of trouble.

12. Take the other map to the Hardening Operations Manager and give him the final "Storage/Disposal/Harden Status Report."

OFFICE PROTECTIVE HOUSEKEEPING PLAN ELEMENTS

Objective: To reduce or eliminate vulnerability of plant property to loss or damage by ceasing non-essential onsite office operations and safeguarding vital records.

INFORMATION FOR COORDINATOR

Whether company operations have been designated **Essential** (to be kept running through the crisis) or otherwise, company vital records can be moved from the risk to the host area.

Vital records are defined as irreplaceable, and necessary to functioning of the company. Such records may include processes, blueprints, and manuals; production and sales records; books and ledgers; stockholder lists; computer tapes; etc.

Records ordinarily replaceable (hence not thought vital) may become technically irreplaceable (i.e., not replaceable in time to achieve some important production goal) or virtually irreplaceable (because the replacement source of the records becomes damaged or destroyed).

INSTRUCTIONS FOR COORDINATOR:

Assign task of defining vital records by department, operations center, function, etc. Let the appropriate head of department, foreman, whatever, analyze day-to-day and other periodic operations and list those records without which he feels his department cannot function. Request that he further assess the potential alternatives if these records were destroyed, to see if effective replacement or substitutions can be made -- using items under company control -- that will allow operations to continue. If not, the particular records are **vital** and should be packaged carefully and relocated to a safe area.

It is possible that some records have already been safeguarded by duplicating them and storing in secured locations. In such case, this may be sufficient, particularly for records used infrequently. However, equipment repair manuals, process information, and similar records may be vital to recovery over the short term immediately after the crisis. Such short-term needs should be part of your consideration and planning.

Vital magnetically stored data and computer tapes should be safeguarded in closed metal boxes, to prevent stray fields from damaging them, and removed to a safe location. Again, duplicate records stored in a second, safe location would be highly desirable.

Make an assessment to determine the volume of vital records as well as the total volume of records. Report both figures to the management team so that final disposition can be decided and scheduled.

Make a checklist of utilities (gas, water, steam, electricity) to be turned off before final evacuation; define the sequence and responsibility for final shutoff at the service entrance; red tag the valves, switches, and controls; and draw a map showing the locations of these items.

Offices are particularly vulnerable to fire damage. Most offices have papers stashed in baskets and racks on desks, calendars hanging on walls, waste paper stuffed in waste baskets, etc. Such conditions make the office extremely vulnerable to a thermal pulse from a nuclear weapon. Wrinkled aluminum foil taped to the inside of all windows will reflect the thermal pulse in a fashion that will not be a hazard to others. But, the blast wave may rupture gas lines, cause electrical shorts (if the power is on) and spread papers to catch fire, even if they are put in drawers. Therefore, all papers (including supplies) should be stored and cared for like flammables/combustibles, and the incidence of fires onsite will be reduced.

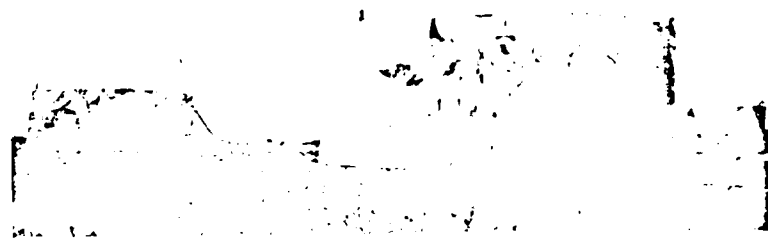


LP-gas bulk storage and filling plant before a nuclear explosion.



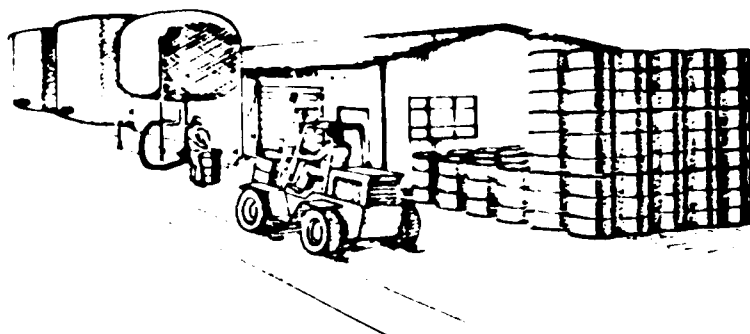
The plant after the explosion (5 psi overpressure).

Fig. 1. EXAMPLE OF THE NEED TO TIE DOWN LOOSE OBJECTS

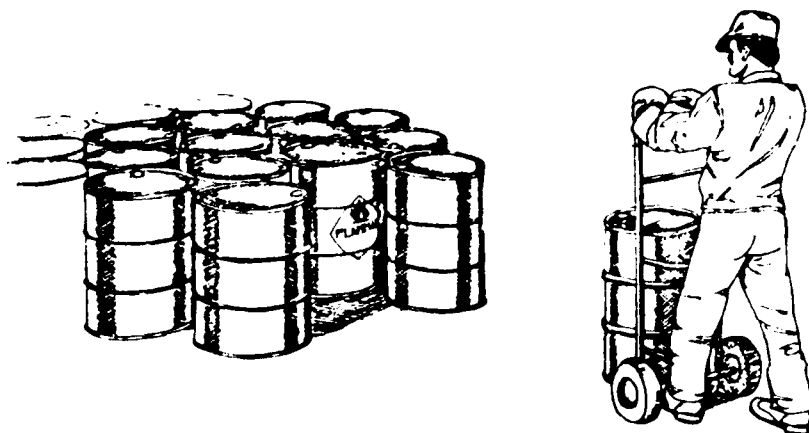


Light missile damage to oil tanks, 0.70 mile from explosion at
Texas City April 16-17, 1947.

Fig. 2. WHAT MISSILES AND AIRBORNE DEBRIS WILL DO



Drain hazardous materials from vulnerable elevated tanks into drums,



then isolate drums in groups strapped together. Be sure all the materials in any one group are compatible (see Table 1). Otherwise, if drums rupture, reactions may be violent.

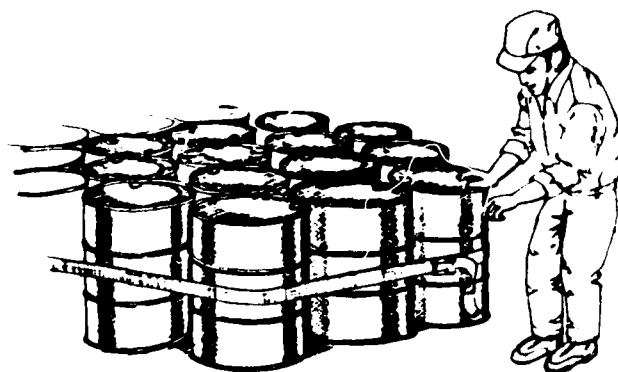


Fig. 3.

TABLE 1: COMMON CHEMICALS

Group I: Hydrocarbons	
a) Gases	b) Liquids
hydrogen	pentane
methane	hexane
ethane	cyclohexane
natural gas	heptane
ethylene	octane
acetylene	benzene
propane	toluene
propylene	xylene
butane	mesitylene
isobutane	ethylbenzene
	gasoline
c) Solid	kerosene
naphthalene	fuel oils
	gasoline (aviation grade)

Group II: Halogenated Compounds	
a) Gases	b) Liquids
methyl chloride	methylene chloride
methyl bromide	chloroform
ethyl chloride	carbon tetrachloride
	ethylene dichloride
	trichloroethane
	trichloroethylene
	chlorobenzene
	dichlorobenzene

Group III: Self-polymerizing Compounds	
a) Gases	b) Liquids
vinyl chloride	formaldehyde-water solution
vinyl bromide	acetaldehyde
butadiene	acrolein
formaldehyde	acrylonitrile
	vinyl acetate
	isoprene
	styrene
	methyl acrylate
	methyl methacrylate
	turpentine

Group IV: Oxides and Peroxide-forming compounds

- | | |
|----------------|-------------------|
| a) Gases | b) Liquids |
| ethylene oxide | propylene oxide |
| dimethyl ether | diethyl ether |
| | tetrahydrofuran |
| | dioxane |
| | dimethoxy ethane |
| | diisopropyl ether |

Group V: Combustible Compounds

- | | |
|----------------------|------------------|
| a) Non-toxic liquids | b) Toxic liquids |
| methanol | methyl mercaptan |
| ethanol | acetonitrile |
| acetone | dimethyl sulfate |
| methyl ethyl ketone | |
| ethyl acetate | c) Solid |
| dimethyl sulfoxide | |
| propyl alcohol | phenol |
| isopropyl alcohol | |
| butanol | |

Group VI: Bases

- | | |
|---------------------|--------------|
| a) Gases | b) Liquids |
| ammonia, anhydrous | ethanolamine |
| methylamine | ethylenimine |
| | aniline |
| c) Solids | pyridine |
| sodium hydroxide | |
| potassium hydroxide | |

Group VII: Acids A

- acetic acid
phosphoric acid

Group VIII: Acids B - Oxidizers

- | | |
|--------------------|------------------|
| a) Gas | b) Liquids |
| nitrogen tetroxide | nitric acid |
| | perchloric acid* |

*store protected from sun.

Group IX: Acids C

- chlorosulfonic acid

Group X: Acid D

- sulfuric acid

Group XI: Poison A

a) Gases

hydrogen chloride
hydrogen fluoride
carbon monoxide
hydrogen sulfide
phosgene

b) Liquids

hydrogen cyanide
carbon disulfide
hydrochloric acid
acetone cyanohydrin

Group XII: Poison B - Miscellaneous

a) Gases

sulfur dioxide
chlorine
boron trifluoride

b) Liquids

bromine

Group XIII: Poison C

Liquid

tetraethyl lead

Group XIV: Poison D

Gas

fluorine

Group XV: Poison E

Solid

phosphorus red
phosphorus white or
yellow

Group XVI: Oxidizers

Solid

ammonium nitrate
ammonium perchlorate

Group XVII: Metals and Derivatives

Solid

lithium
sodium
potassium
magnesium
calcium hydride

Group XVIII: Non-Metals Derivatives

a) Liquids

sulfur trioxide, oleum
sulfuryl chloride
thionyl chloride
phosphorus trichloride
phosphorus oxychloride
titanium tetrachloride

b) Solids

phosphorus pentoxide
phosphorus pentasulfide

PROTECTIVE HOUSEKEEPING WORK PARTY STATUS FORM

REGION	Estimated Time to Complete	Completed	DIFFICULTIES ENCOUNTERED (OR FORESEEN) WHERE HELP IS NEEDED	Time of Entry
SIZE OF COLLECTION	Debris: _____ Delicate Equipment: _____ Heavy Equipment: _____			

PROTECTIVE HOUSEKEEPING WORK PARTY STATUS FORM

REGION	Estimated Time to Complete	% Completed	DIFFICULTIES ENCOUNTERED (OR FORESEEN) WHERE HELP IS NEEDED	Time of Entry
SIZE OF COLLECTION	Debris: _____ Delicate Equipment: _____ Heavy Equipment: _____			

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PROTECTIVE HOUSEKEEPING WORK PARTY STATUS FORM

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SIZE OF COLLECTION	Debris: _____ Delicate Equipment: _____ Heavy Equipment: _____			

PROTECTIVE HOUSEKEEPING WORK PARTY STATUS FORM

REGION	Estimated Time to Complete	Completed	DIFFICULTIES ENCOUNTERED (OR FORESEEN) WHERE HELP IS NEEDED	Time of Entry
SIZE OF COLLECTION	Debris: _____ Delicate Equipment: _____ Heavy Equipment: _____			

STORAGE/DISPOSAL STATUS REPORT

Time: _____

Estimated Time to Complete: _____

Estimated Percentage Completed: _____

Size of Present Debris Pile: _____

Size of Present Delicate Equipment Collection: _____

Size of Present Heavy Equipment Collection: _____

Size of Present Hazardous Materials Collection: _____

ALTERNATIVE SOLUTIONS FOR SAFE STORAGE OR DISPOSAL:

	MOVE *	BURY *	TIE DOWN *
DEBRIS			
DELICATE EQUIPMENT			
HEAVY EQUIPMENT			
HAZARDOUS MATERIALS			

* In each box, list resources required and estimated time to complete.

STORAGE/DISPOSAL STATUS REPORT

Time: _____

Estimated Time to Complete: _____

Estimated Percentage Completed: _____

Size of Present Debris Pile: _____

Size of Present Delicate Equipment Collection: _____

Size of Present Heavy Equipment Collection: _____

Size of Present Hazardous Materials Collection: _____

ALTERNATIVE SOLUTIONS FOR SAFE STORAGE OR DISPOSAL:

	MOVE *	BURY *	TIE DOWN *
DEBRIS			
DELICATE EQUIPMENT			
HEAVY EQUIPMENT			
HAZARDOUS MATERIALS			

* In each box, list resources required and estimated time to complete.

STORAGE/DISPOSAL STATUS REPORT

Time:

Estimated Time to Complete:

Estimated Percentage Completed:

Size of Present Debris Pile:

Size of Present Delicate Equipment Collection:

Size of Present Heavy Equipment Collection:

Size of Present Hazardous Materials Collection:

ALTERNATIVE SOLUTIONS FOR SAFE STORAGE OR DISPOSAL:

	MOVE *	BURY *	TIE DOWN *
DEBRIS			
DELICATE EQUIPMENT			
HEAVY EQUIPMENT			
HAZARDOUS MATERIALS			

* In each box, list resources required and estimated time to complete.

STORAGE/REMOVAL STATUS REPORT

Time:

Estimated Time to Complete:

Estimated Percentage Completed:

Size of Present Debris Pile:

Size of Present Delicate Equipment Collection:

Size of Present Heavy Equipment Collection:

Size of Present Hazardous Materials Collection:

ALTERNATIVE SOLUTIONS FOR SAFE STORAGE OR DISPOSAL:

	MOVE *	BURY *	TIE DOWN *
DEBRIS			
DELICATE EQUIPMENT			
HEAVY EQUIPMENT			
HAZARDOUS MATERIALS			

* In each box, list resources required and estimated time to complete.

INDUSTRIAL PROTECTION GUIDE

**CRISIS RELOCATION
INDUSTRIAL HARDENING PLAN**

**RESOURCE
INVENTORY**

APPENDIX A

APPENDIX B

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 5

HARDENING RESOURCES INVENTORY

This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

Booklet 5

Alternate: _____
(name)

Objective: To develop a list of resources available to your plant for "hardening" and recovery.

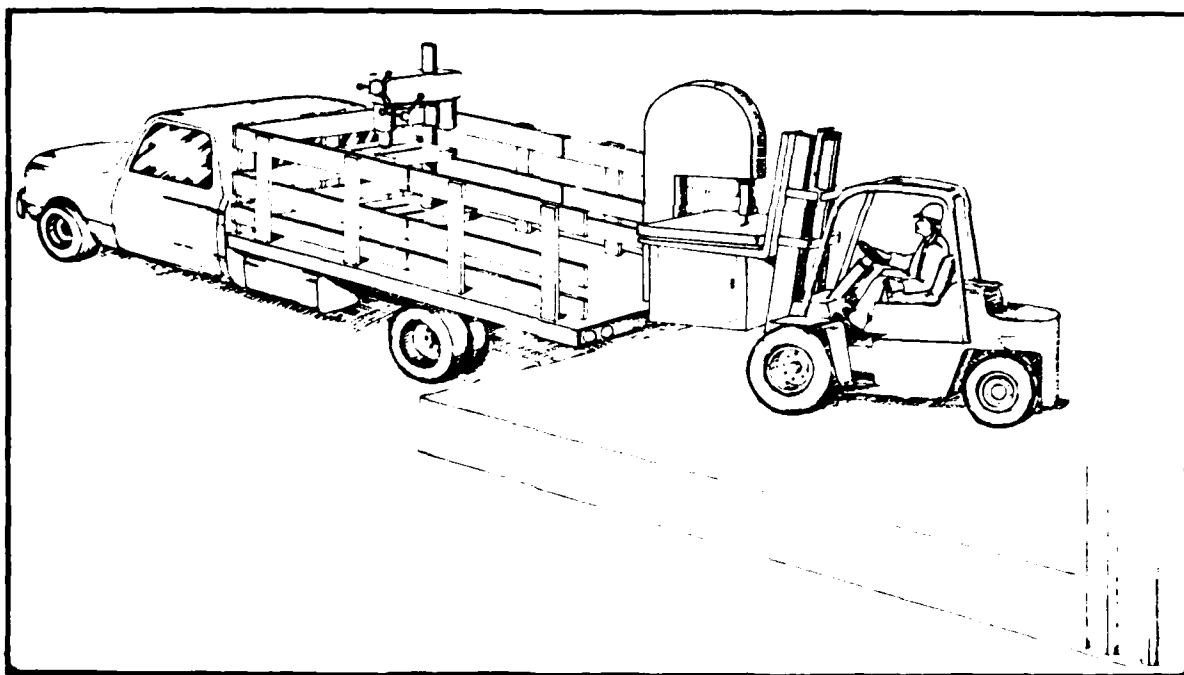
This booklet is part of a plan to protect industrial plant equipment from possible damage in the event of a nuclear attack. It leads to a surveyed list of resources available to carry out the various plan elements that might be developed to harden the facility and to return it rapidly to production after the crisis is over. Hardening alternatives involve the movement of personnel, records, equipment to low-risk (non-target) areas; construction of revetments, berms, burial pits for equipment; lashing down packaged and cushioned equipment with cable, rope, chain link fencing; disassembly of vulnerable structures, etc. Returning the facility to production requires tools, materials handling equipment, power distribution systems, etc., which may no longer be functioning or available, if left onsite. These resources should be evacuated to the host area so they will be in your hands when you are ready for them.

In the first few pages of this booklet you will find some illustrations of methods for protecting (hardening) plant equipment. These illustrations will help you to identify the resources to be inventoried. Similar illustrations have been provided to distribute with the inventory forms included in the last part of this booklet to help you inventory resources in your plant quickly and efficiently.

The Coordinator assigned to direct the taking of this inventory should review the total concept of industrial hardening with management. Because materials and equipment on hand may change frequently, this inventory will have to be current at the time hardening is to commence.

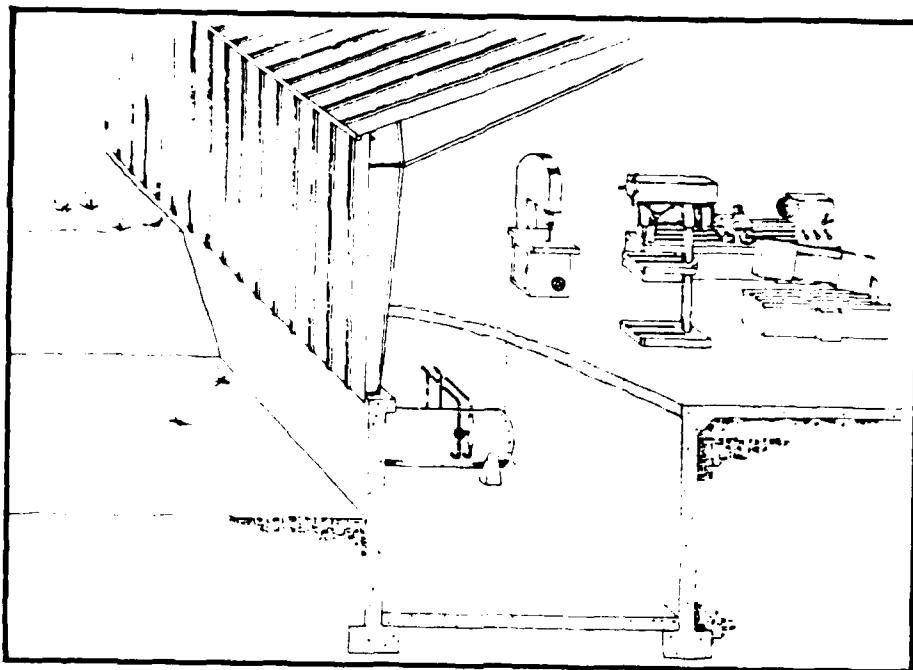
IN THE PRESENT CRISIS

To protect (harden) equipment needed for continued survival,
resources are required to do the following.



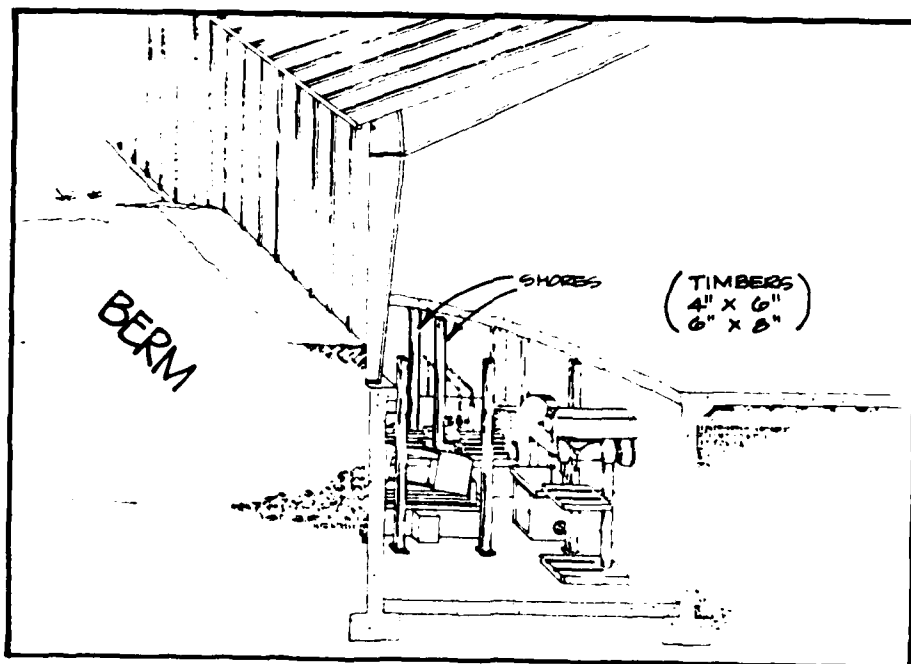
LOAD EQUIPMENT AND MOVE IT AWAY

MOVE EQUIPMENT TO SAFER PLACE IN THE PLANT STRUCTURE
AND HARDEN STRUCTURE . . .



TO HARDEN STRUCTURE
(It Must Have a Basement!)

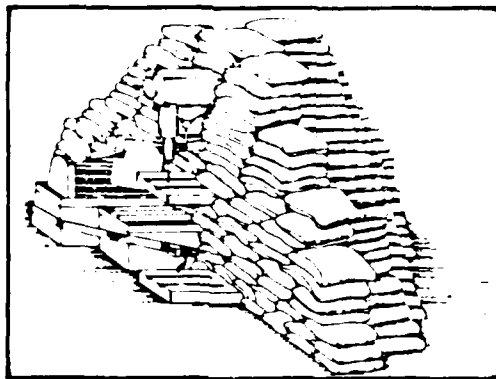
Reinforce basement space with supporting tim-
bers (shores). Berm outside walls to floor line.



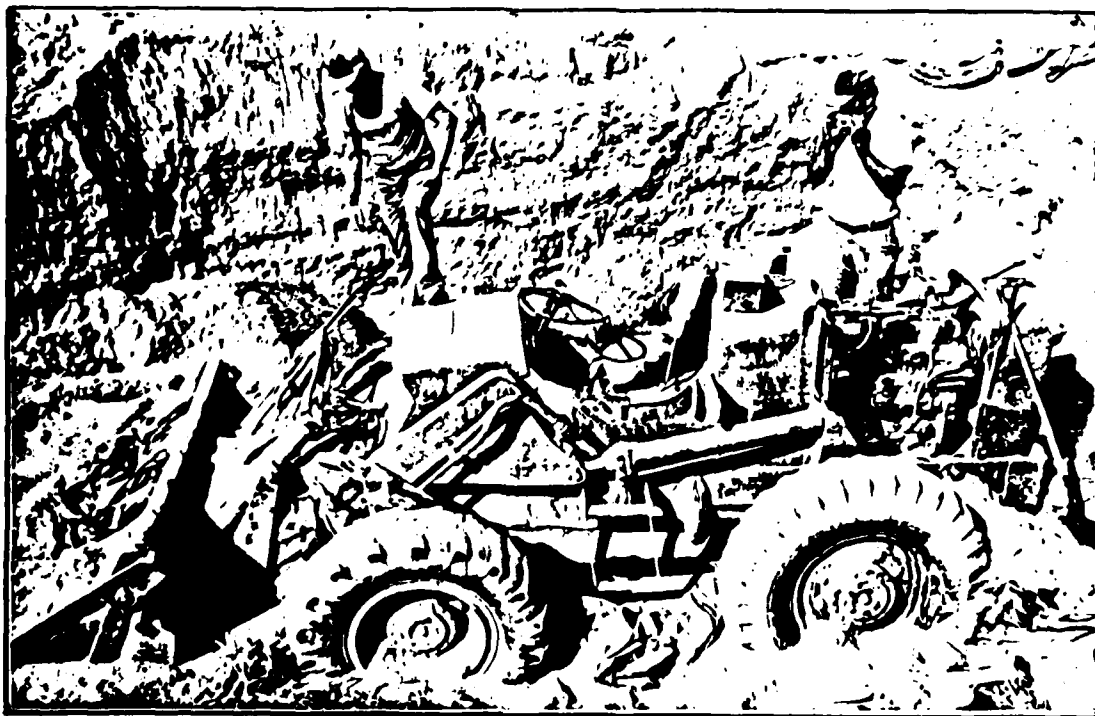
RELOCATE EQUIPMENT UNDERGROUND IN SHORED BASEMENT

IF YOU CAN MOVE THE EQUIPMENT BUT CAN'T HAUL IT AWAY . . .

BURY IT OUTDOORS

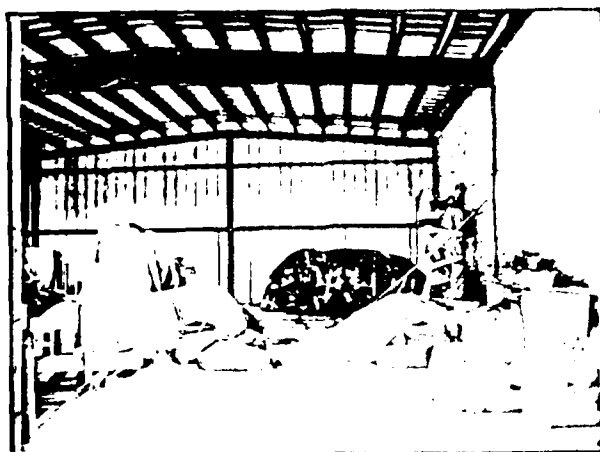


In Paved Areas - Sandbag It

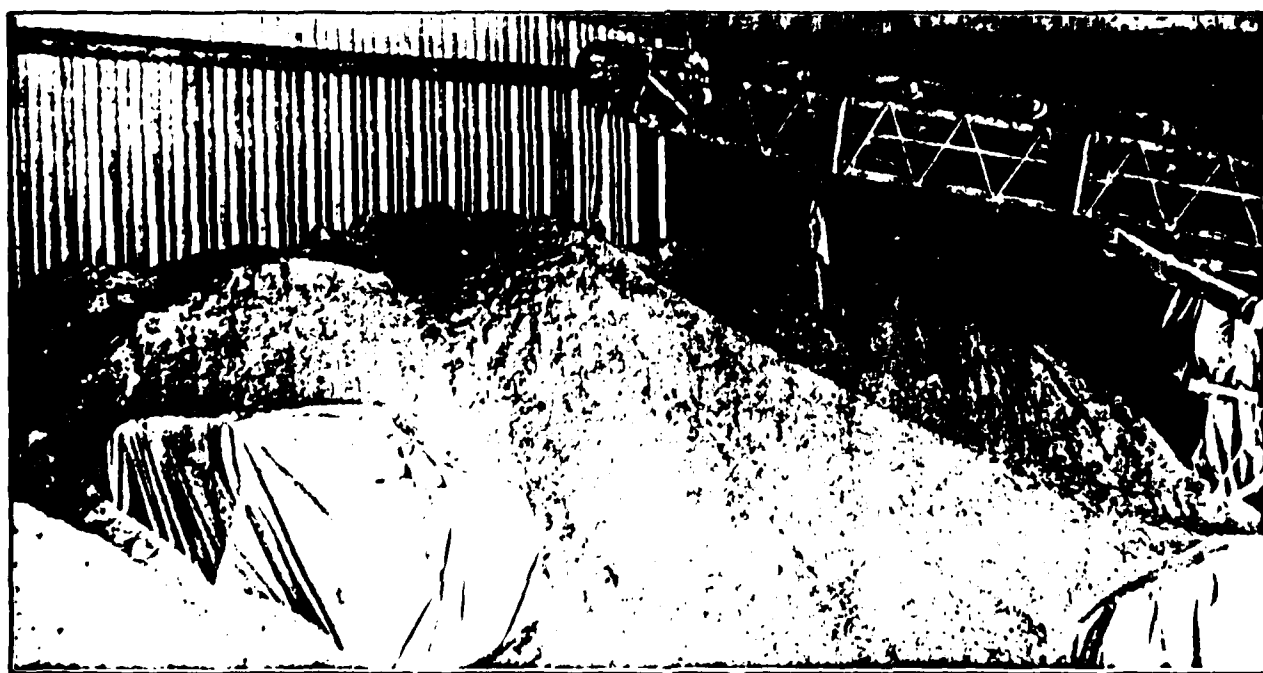


IN OPEN AREAS - PUT IT IN A TRENCH
(COVER IT IF THERE IS TIME)

IF YOU CAN'T MOVE EQUIPMENT . . .

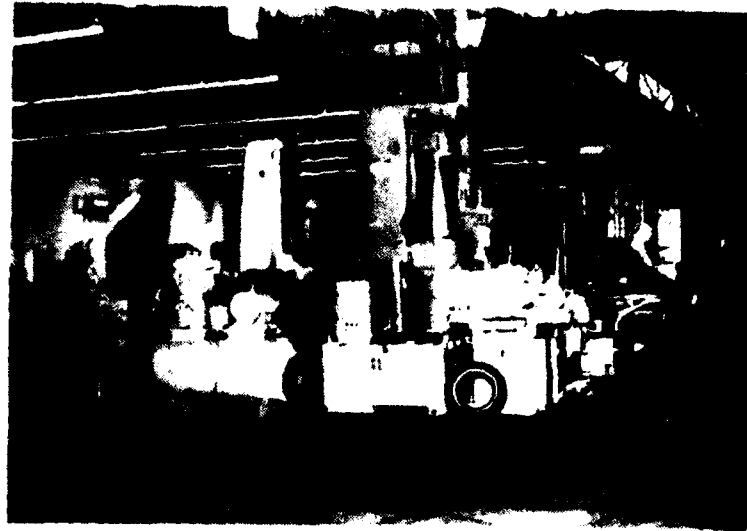


Crushable packing held in place by plastic sheet
for burial protection.

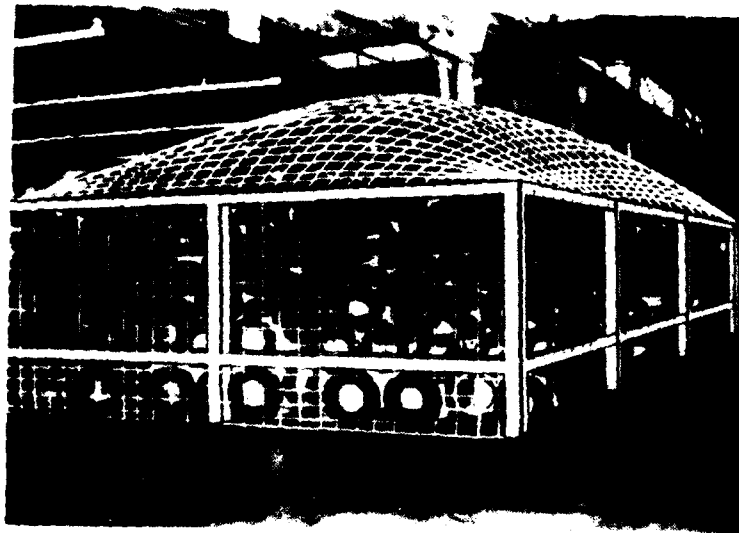


BURY IT IN PLACE INDOORS.

IF YOU CAN'T BURY OR MOVE IT . . .



Cluster movable equipment around it; wedge wood or tire bumpers between equipment to protect knobs, handles, etc.



Weld I-beam grill around it; add chain link fence; stuff with tires or lumber; and cover.

INSTRUCTIONS FOR COORDINATOR:

To inventory and list the materials and equipment previously pictured, the following plan can be put into effect.

Divide your facility into areas. Choose areas so resources in each can be inventoried in approximately one or two hours.

Divide available personnel into two-man teams, so that each team covers an area, and assign a team leader and a recorder; where possible, assign personnel familiar with the area covered.

Detach forms and distribute to the teams. (Forms are in the back of this booklet.)

A sample of a completed form can be found on page 12 of this booklet.

Review the instructions here and on the following page with each team, then:

Select a coding system for tagging resources so all resources of one type have the same mark, tag, or color.

If sufficient personnel are available, consider a roving supervisor between teams. This person can aid some teams that may falter; he should be someone familiar with the total plan.

Again if sufficient personnel are available, appoint a runner to collect and return completed forms to you.

Return the completed forms to the Hardening Operations Manager.

OFFSITE RESOURCES:

If sufficient personnel are available, or at the end of the onsite inventory, a team or two should be assigned the task of assessing the offsite resources that are available for use. In most industrial complexes it is likely that a variety of facilities exist, each with different types of equipment and supplies. Arrangements to use needed outside resources should be made either through previously arranged mutual aid agreements or by on-the-spot trades.

Examples of trades or exchanges might be: Temporary use of a forklift in exchange for packing materials; spare cable for sand and gravel; or excess labor for any needed commodity.

All offsite resources should be identified on a separate resource sheet and all trades should be coordinated through the management team.

STANDARD PRODUCTION RATE — PRIMARY EQUIPMENT

Horsepower Rating	REAR-DUMP				MOTOR PLAINERS			
	CRAWLER		WHEEL		WHEEL		WHEEL	
	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr
Up to 150	280	140	-	-	141	160	-	-
150 to 200	282	230	283	190	143	200	-	-
200 to 250	284	330	285	275	145	280	-	-
250 to 300	286	400	287	350	-	-	-	-
Over 300	288	520	289	530	-	-	-	-

Table from "What the
Planner Needs to Know,"
Jacobs Associates, San
Francisco, June 1975.

Horsepower Rating	FRONT-END LOADERS				SIDE-DUMP			
	END-DUMP		WHEEL		CRAWLER		WHEEL	
	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr	Code Number	Std Prod Rate cu yd/hr
Up to 150	160	100	161	130	170	125	171	155
150 to 200	162	140	163	185	172	190	173	220
200 to 250	164	185	165	250	174	215	175	300
250 to 300	166	245	167	320	176	290	177	400
Over 300	-	-	169	430	-	-	179	525

For those who wish to barter for use of equipment, this table indicates production rates (in cubic yards per hour that can be moved around in a plant by a qualified operator).

INVENTORY FOR RECOVERY:

Equipment will be required to remove the debris from protected production equipment. Winches, bulldozers, etc., will be needed to uncover the equipment, and maintenance and repair tools, maintenance and repair manuals, etc., will be needed to get equipment back into operation.

Equipment that will be required during the recovery period will include some of that used during hardening. This inventory should be divided into two lists: one list should contain those items needed for post-attack recovery that will also be used for hardening. The other list should contain only those items critical to recovery that will not be needed until then, such as maintenance and repair tools, repair manuals, spare parts, fuel, truck-mounted winches. These may be evacuated early. The former list of recovery equipment will have to be scheduled for later evacuation.

Only that equipment required for recovery that you can easily dig out later with evacuated tools and resources should be hardened onsite -- otherwise recovery equipment should be evacuated, or it may become buried in rubble and inaccessible.

INSTRUCTIONS FOR TEAM MEMBERS:

Collect necessary equipment: Clipboard, or equivalent, pencils or pens, measuring tool, and inventory forms to compile the inventory. There are seven sets of inventory forms for listing seven categories of resources.

Take flags, markers, or spray paint to mark items inventoried to avoid double counting or missing of items. Seven different marking codes will simplify allocations of resources later.

Use a different form for each type of resource being inventoried and code all items in one category with the same marking. Use illustrations and lists provided with each set of forms to help you decide what to list in each category.

Enter your team number, the location of the area inventoried, the number of the sheet completed, and the color code or other method of identifying the material in the category you have inventoried.

Write brief descriptions of the items or groups of items and their locations.

Estimate quantity and size of stacks or piles of materials; don't take time to count every piece.

Return completed forms to the Coordinator.

RESOURCE INVENTORY SHEET

HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM # 3

AREA BLdg. 112A CODE (IF USED) Red SHEET # 1

ITEM #	DESCRIPTION & LOCATION	QUANTITY
1	DEBRIS box 2 yds. capacity Bay 4	3
2	FORK lift 4,000 lbs Bay 5	2
3	CONVEYOR 25' with motor Bay 6	1
4	PRECAST slabs 8" x 4' x 16' yard behind building	about 50
5	" " 6" x 4' x 12' "	about 30
6	PRECAST columns 1' x 2' x 12' "	about 150
7	CEMENT sacks 100 lbs Back shed	about 80
8	PRECAST forms misc. Yard	cover about 1,000 ft ²
9		
10		
11		
12		
13		
14		

RESOURCE INVENTORY FORMS

1. For Lifting, Moving, Transportation
2. Shelter Construction/Upgrading
3. Ditching & Berming
4. Crushable Materials & Light Covering Material
5. Heavy Duty Materials & Equipment
for Covering & Burying
6. For Fastening and Anchoring
7. Recovery

FOR LIFTING, MOVING, TRANSPORTATION



Highway

stake truck
flat bed
U-haul trailer
van
tanker
dump truck
cement truck
dumpster

Rail

flatcar
boxcar
hopper car
tank car

Waterways

barge
garbage scow
raft
ferry



In Plant

crane
gantry
forklift
endloader
cherry picker
jacks
bridge crane
rollers

RESOURCE INVENTORY SHEET

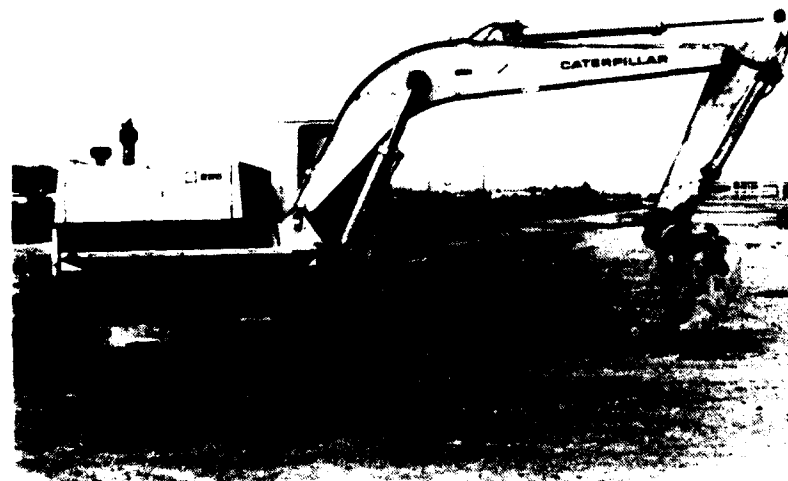
FOR LIFTING, MOVING, TRANSPORTING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel
conveyor
wheelbarrow
endloader
grader
backhoe
tractor
picks
saws

hammer
sledge
axe
generator
batteries
pumps
blower
A-frames
winches

Materials

nails
plywood
lumber
railway ties
pipe
concrete block
precast concrete

RESOURCE INVENTORY SHEET

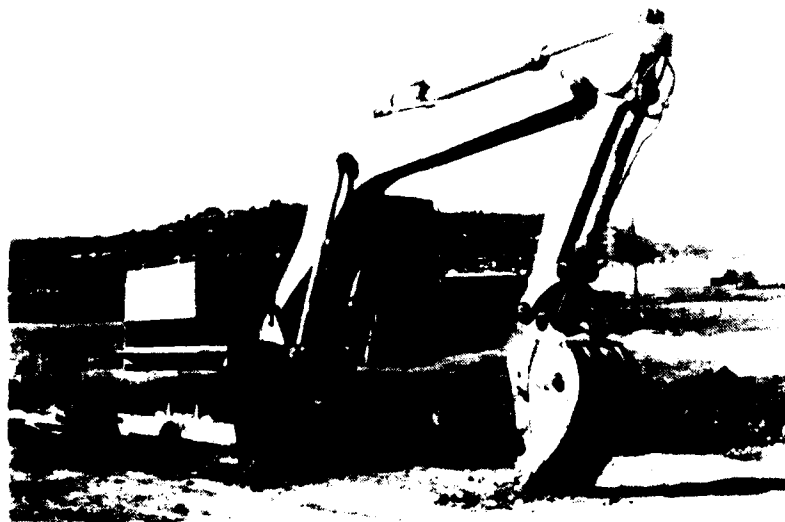
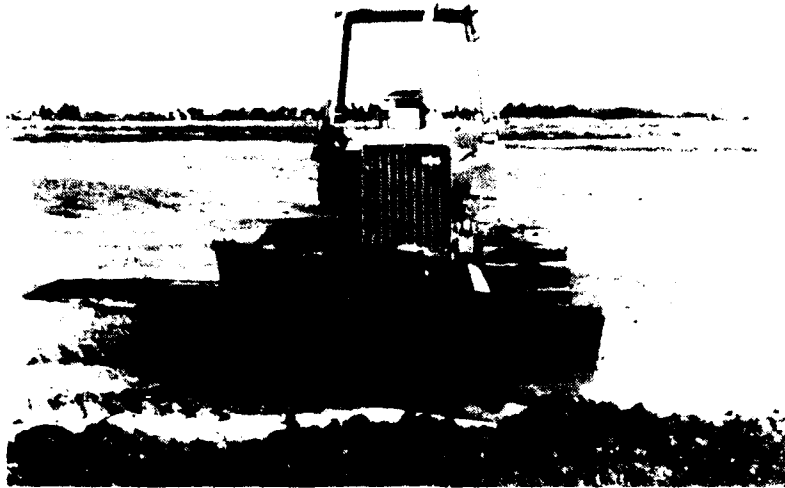
SHELTER CONSTRUCTION/UPGRADING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

DITCHING & BERMING



Equipment
grader
end loader
ditch diggers
scrapers
trucks
backhoes
tractors

RESOURCE INVENTORY SHEET

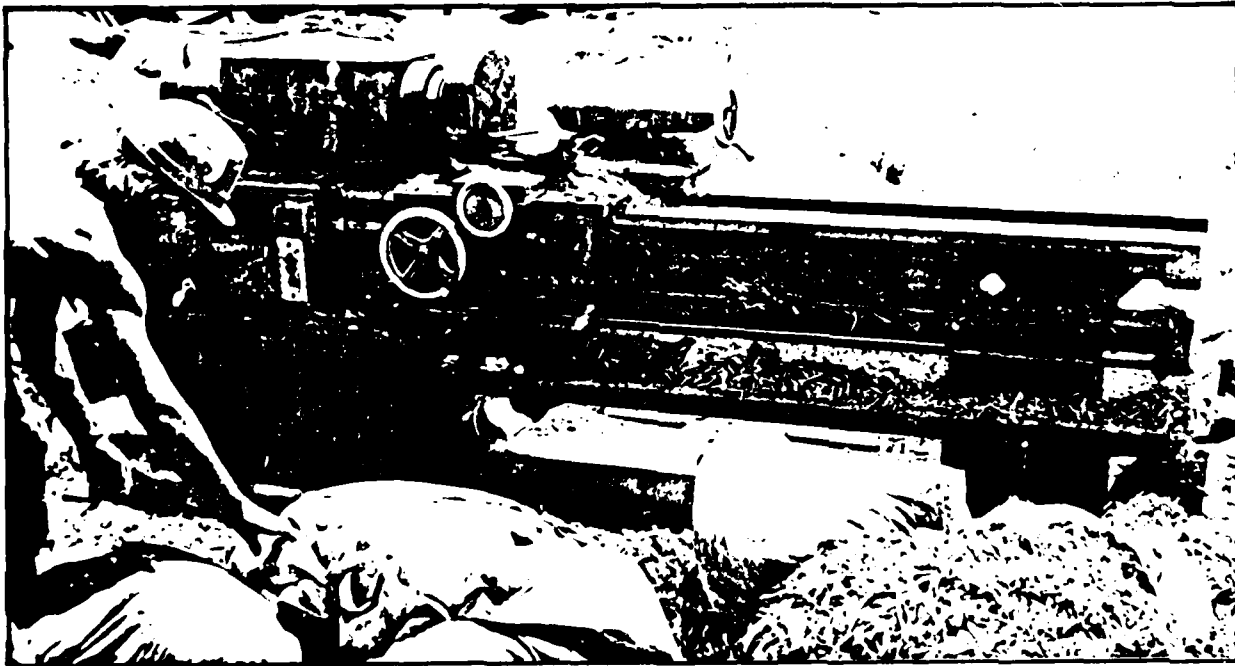
DITCHING & BERMING EQUIPMENT

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



— CRUSHABLE PACKING —

HAY	PAPER
STRAW	CARDBOARD
EXCELSIOR	STYROFORM
METAL SHAVINGS	FIBERGLAS BATTS
WOOD CHIPS	PERLITE

— LIGHT COVERING —

MICA	TAR PAPER	NEWSPRINT
MINERAL WOOD	RUGS	LINOLEUM
CORK BOARD	SHEETS	CANVAS
GRAIN	PLASTIC FILM	RUBBER SHEETING
SAWDUST		
TIRRS		

RESOURCE INVENTORY SHEET

CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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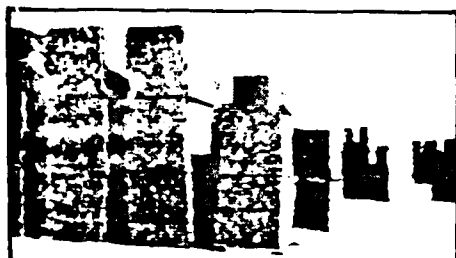
HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



BULLDOZER



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



LUMBER STACKS



MATERIALS

DIRT
SAND
GRAVEL
PLYWOOD
LUMBER
CONCRETE SLABS
CONCRETE PIERS
METAL PLATES
BRICK
CONCRETE BLOCK

COAL
RUBBLE
CHAIN LINK FENCE
SAND BAGS
CEMENT SACKS

EQUIPMENT

BULLDOZER
END LOADER
SNOW PLOW
GRADER
TRACTOR
CONVEYOR
FORK LIFT
WITH DEBRIS BOX
DUMPSTER

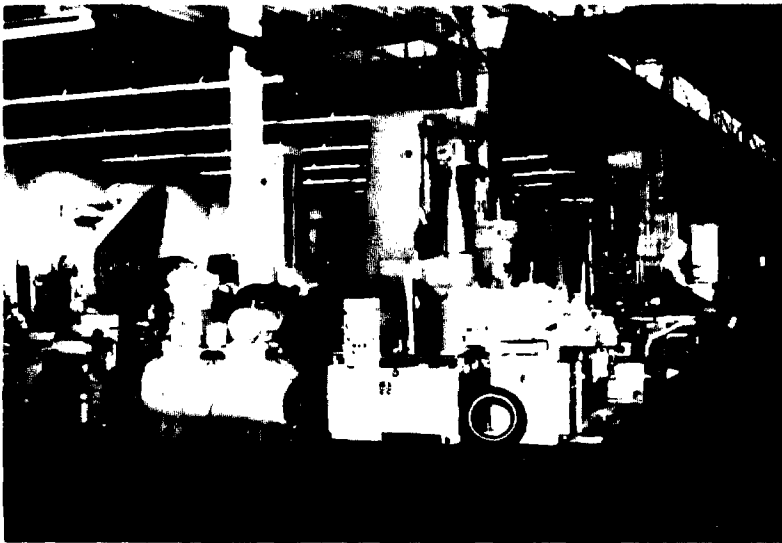
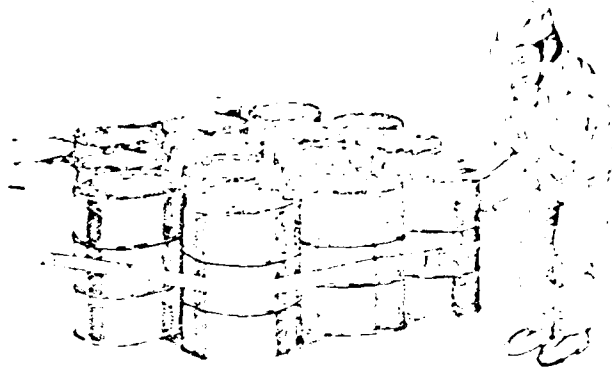
RESOURCE INVENTORY SHEET

HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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FOR FASTENING AND ANCHORING

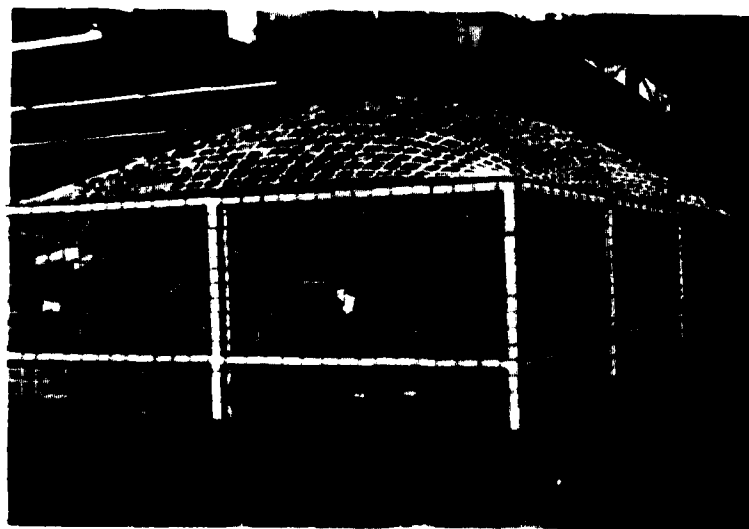


Fastening Materials

wire
cable
trucker strapping
webbing
reinforcing wire
beams and channel
welding rod
chain link fence
cable clamps
turnbuckle

Anchors

pipe
angle iron
rebar
light standards
telephone poles
concrete blocks



RESOURCE INVENTORY SHEET

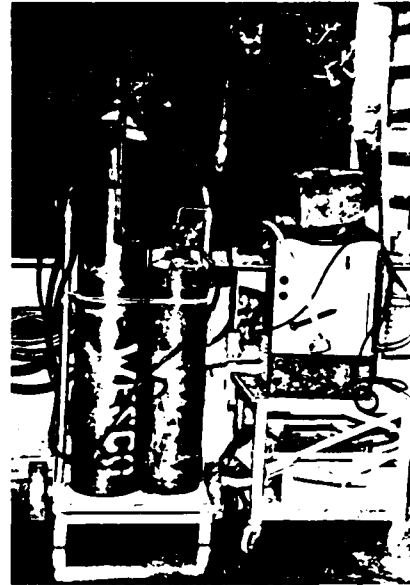
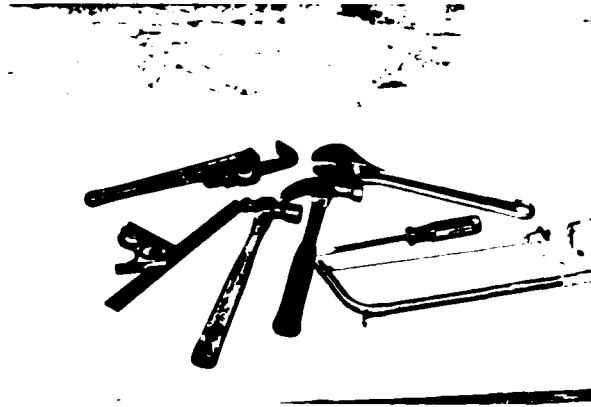
FASTENING & ANCHORING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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RECOVERY



Lifting & Moving Equipment

A-frame
backhoe
end loader
winch
tractor
truck
bulldozer

Maintenance & Repair

welder
torch
hand torch
machine tools
hand tools
equipment manual
repair manual
grinder
generator

Safety

radiac equipment
disposable work clothes
mobile pump units
water tankers
ditching equipment

RESOURCE INVENTORY SHEET

RECOVERY

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
1		
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FOR LIFTING, MOVING, TRANSPORTATION



Highway

stake truck
flat bed
U-haul trailer
van
tanker
dump truck
cement truck
dumpster

Rail

flatcar
boxcar
hopper car
tank car

Waterways

barge
garbage scow
raft
ferry



In Plant

crane
gantry
forklift
endloader
cherry picker
jacks
bridge crane
rollers

RESOURCE INVENTORY SHEET

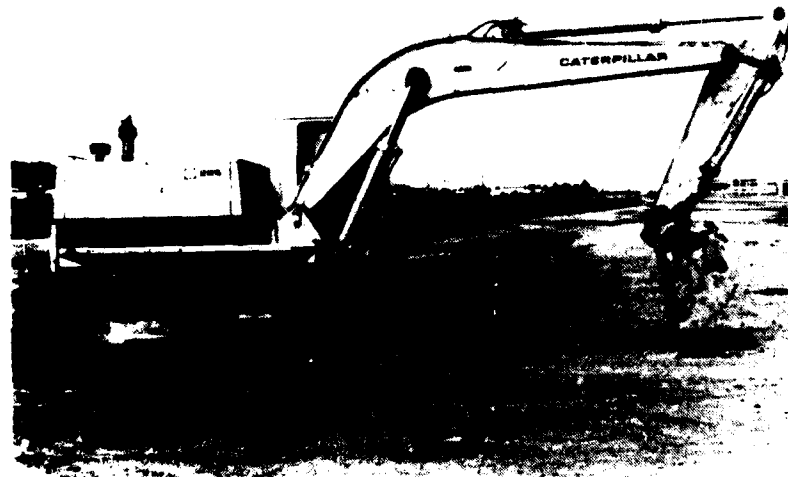
FOR LIFTING, MOVING, TRANSPORTING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

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SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel
conveyor
wheelbarrow
endloader
grader
backhoe
tractor
picks
saws

hammer
sledge
axe
generator
batteries
pumps
blower
A-frames
winches

Materials

nails
plywood
lumber
railway ties
pipe
concrete block
precast concrete

RESOURCE INVENTORY SHEET

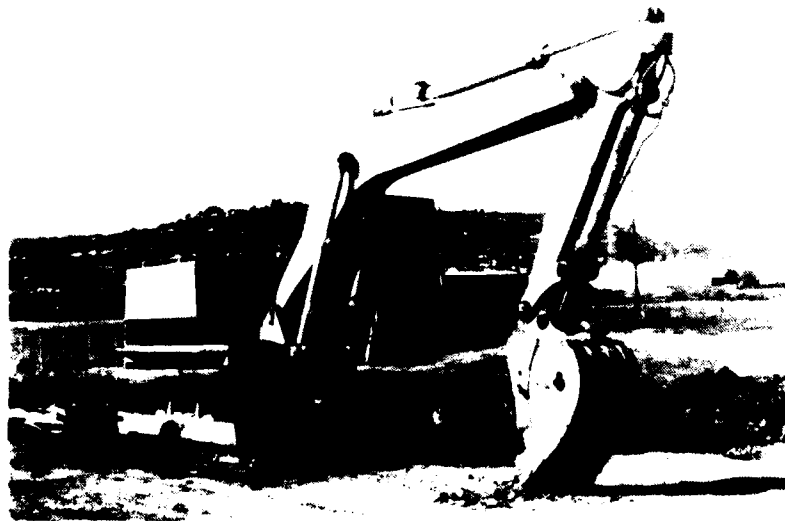
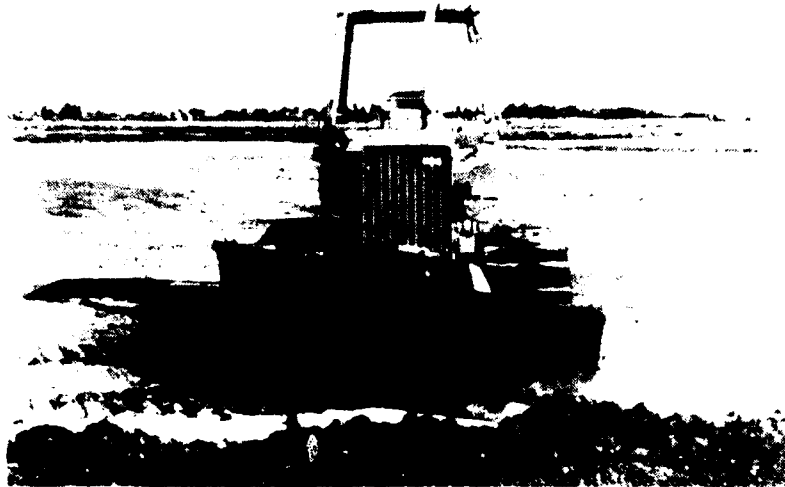
SHELTER CONSTRUCTION/UPGRADING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

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DITCHING & BERMING



Equipment

grader
end loader
ditch diggers
scraper
trucks
backhoes
tractors

RESOURCE INVENTORY SHEET

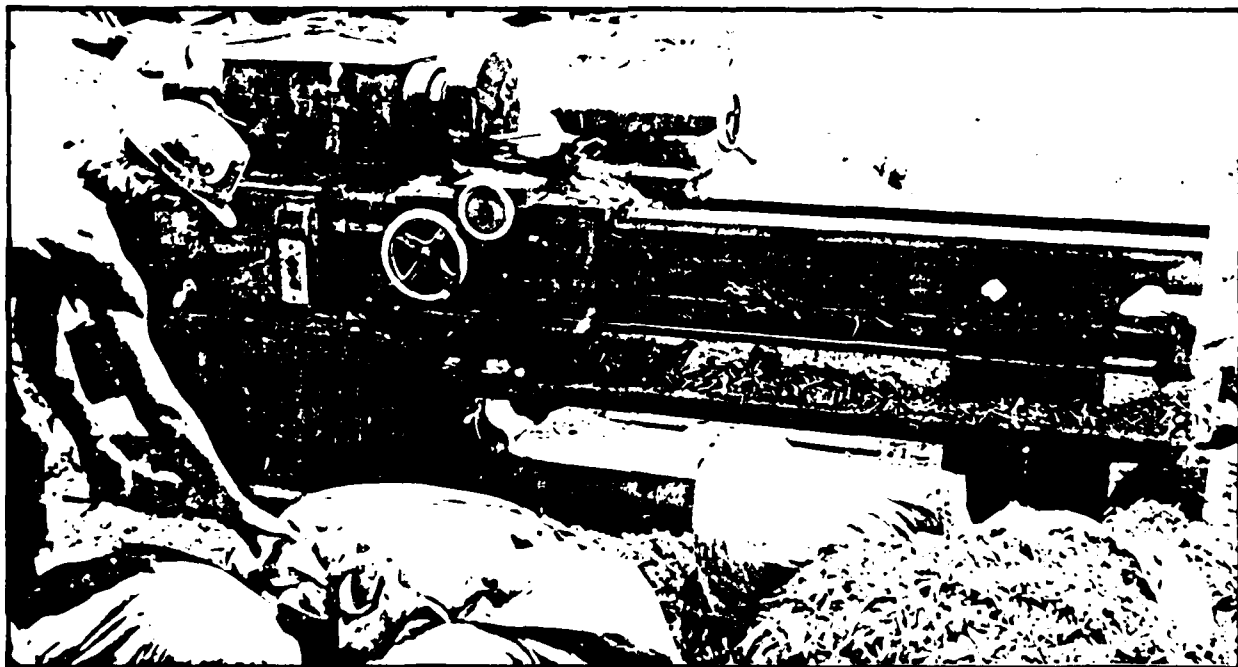
DITCHING & BERMING EQUIPMENT

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



— CRUSHABLE PACKING —

HAY	PAPER
STRAW	CARDBOARD
EXCELSION	STYROFORM
METAL SHAVINGS	FIBERGLAS BATTS
WOOD CHIPS	PERLITE

— LIGHT COVERING —

MICA	TAR PAPER	NEWSPRINT
MINERAL WOOD	RUGS	LINOLEUM
CORK BOARD	SHEETS	CANVAS
GRAIN	PLASTIC FILM	RUBBER SHEETING
SAWDUST		
TIRES		

RESOURCE INVENTORY SHEET

CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL

TEAM # _____

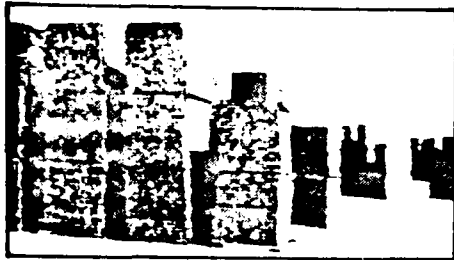
AREA _____ CODE (IF USED) _____ SHEET # _____

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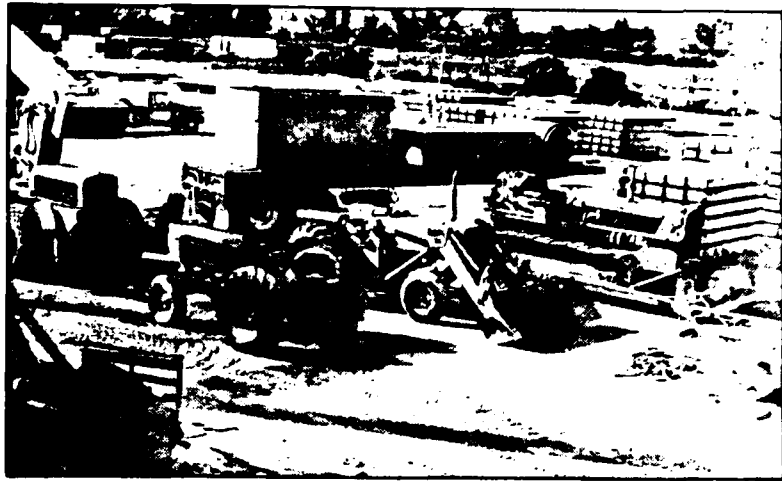
HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



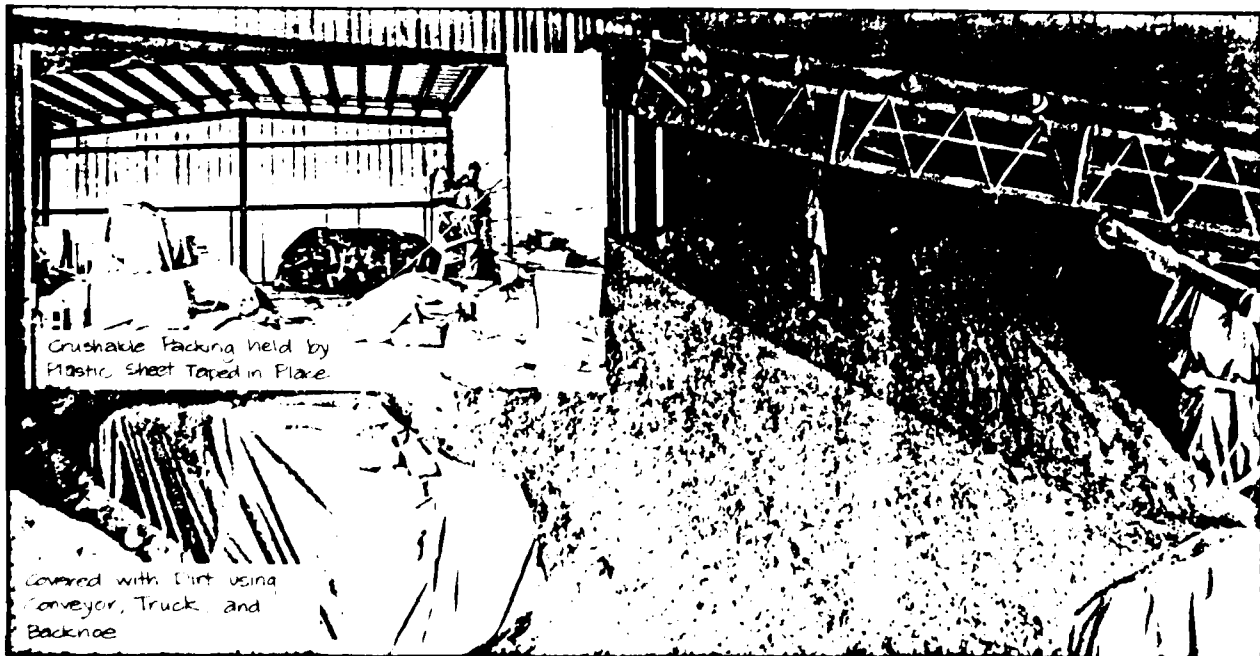
BULLDOZER



LUMBER STACKS



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



MATERIALS

DIRT
SAND
GRAVEL
PLYWOOD
LUMBER
CONCRETE SLABS
CONCRETE PIERS
METAL PLATES
BRICK
CONCRETE BLOCK

COAL
RUBBLE
CHAIN LINK FENCE
SAND BAGS
CEMENT SACKS

EQUIPMENT

BULLDOZER
END LOADER
SNOW PLOW
GRADER
TRACTOR
CONVEYOR
FORK LIFT
WITH DEBRIS BOX
DUMPSTER

RESOURCE INVENTORY SHEET

HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM #

AREA CODE (IF USED) SHEET #

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F/G 15/3

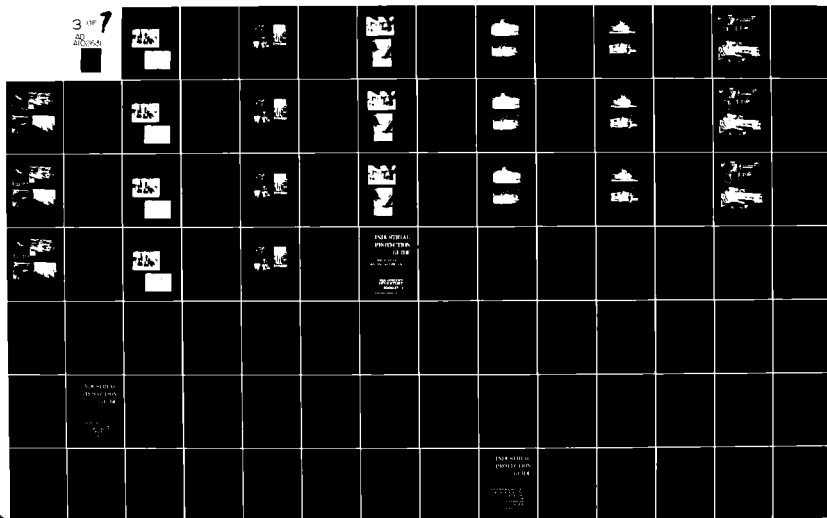
JUN 81

UNCLASSIFIED SSI-8011

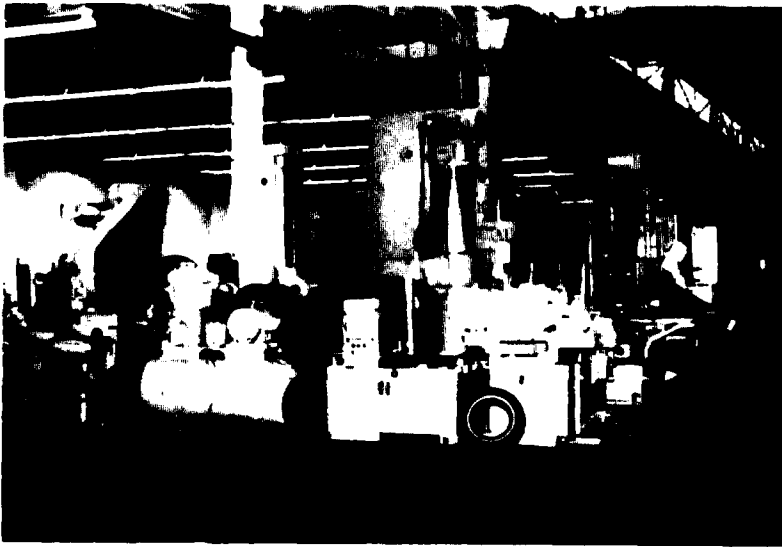
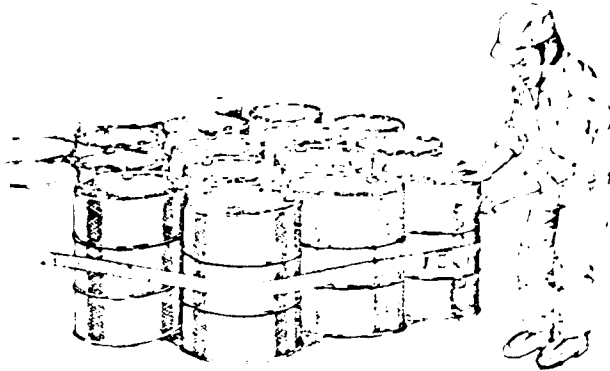
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3 OF 7
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FOR FASTENING AND ANCHORING

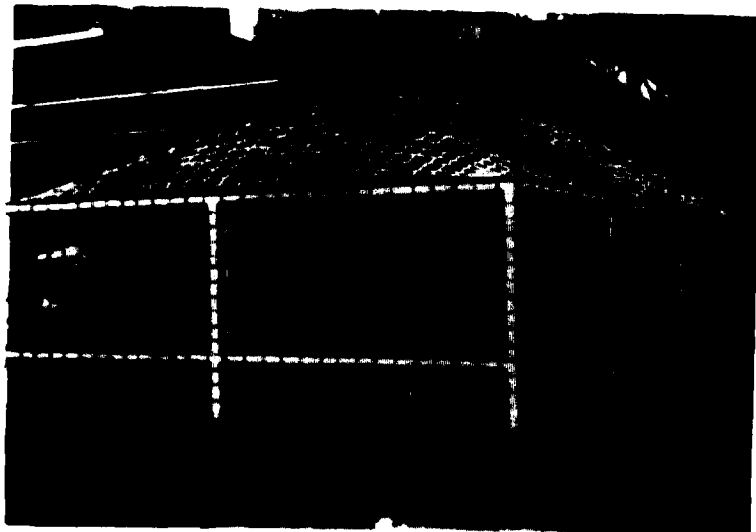


Fastening Materials

wire
cable
trucker strapping
webbing
reinforcing wire
beams and channel
welding rod
chain link fence
cable clamps
turnbuckle

Anchors

pipe
angle iron
rebar
light standards
telephone poles
concrete blocks



RESOURCE INVENTORY SHEET

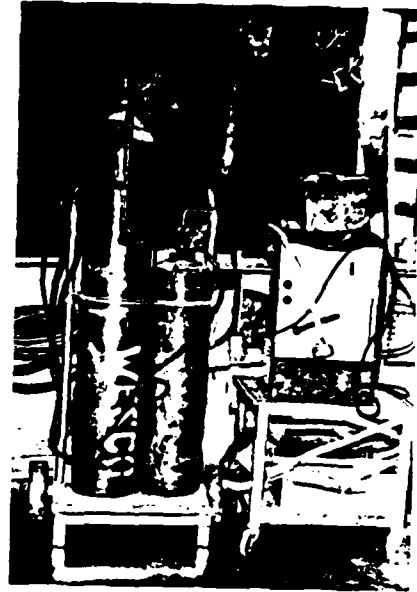
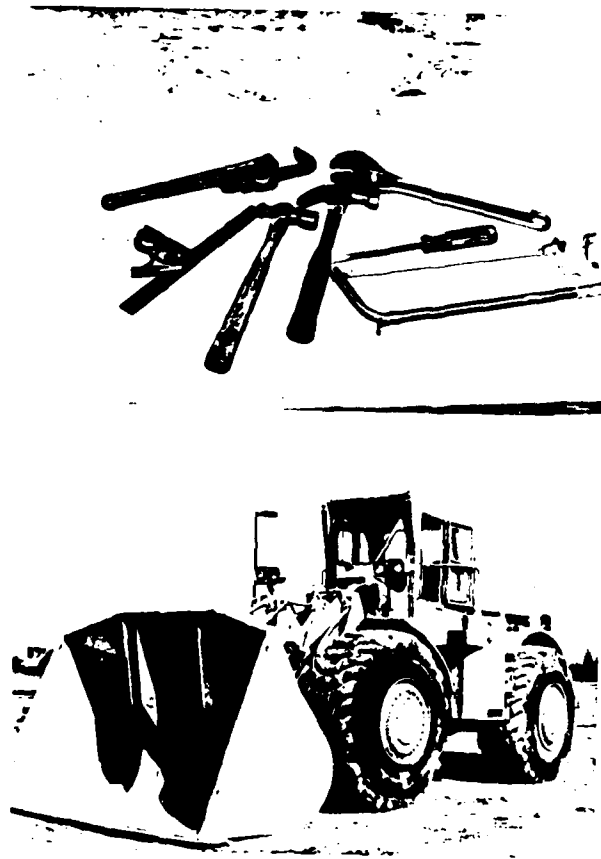
FASTENING & ANCHORING

TEAM # _____

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RECOVERY



Lifting & Moving Equipment

A-frame
backhoe
end loader
winch
tractor
truck
bulldozer

Maintenance & Repair

welder
torch
hand torch
machine tools
hand tools
equipment manual
repair manual
grinder
generator

Safety

radiac equipment
disposable work clothes
mobile pump units
water tankers
ditching equipment

RESOURCE INVENTORY SHEET

RECOVERY

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
1		
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13		
14		

FOR LIFTING, MOVING, TRANSPORTATION



Highway

stake truck
flat bed
U-haul trailer
van
tanker
dump truck
cement truck
dumpster

Rail

flatcar
boxcar
hopper car
tank car

Waterways

barge
garbage scow
raft
ferry



In Plant

crane
gantry
forklift
endloader
cherry picker
jacks
bridge crane
rollers

RESOURCE INVENTORY SHEET

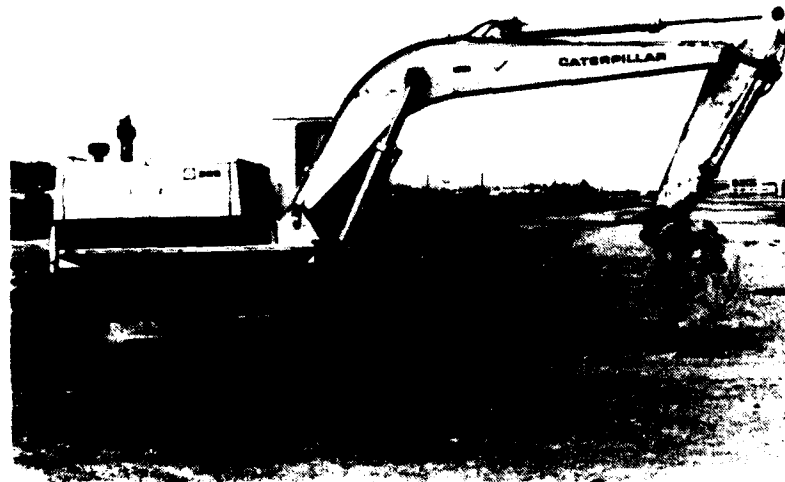
FOR LIFTING, MOVING, TRANSPORTING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
1	_____	_____
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11	_____	_____
12	_____	_____
13	_____	_____
14	_____	_____

SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel
conveyor
wheelbarrow
endloader
grader
backhoe
tractor
picks
saws

hammer
sledge
axe
generator
batteries
pumps
blower
A-frames
winches

Materials

nails
plywood
lumber
railway ties
pipe
concrete block
precast concrete

RESOURCE INVENTORY SHEET

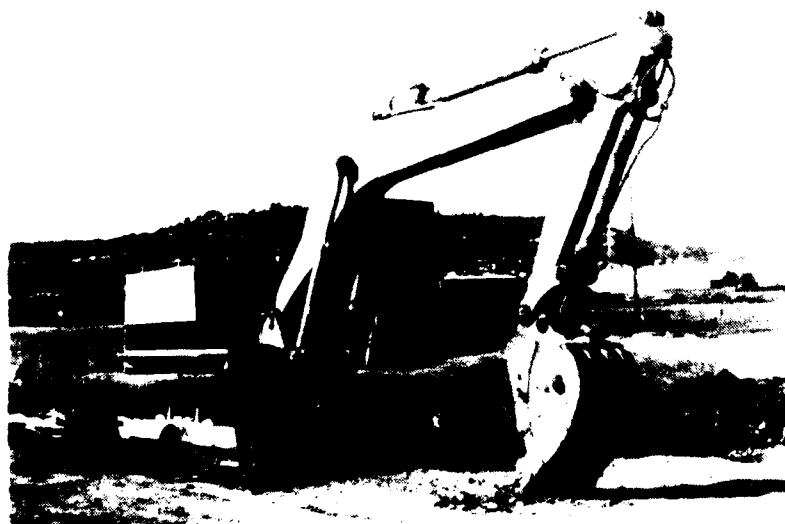
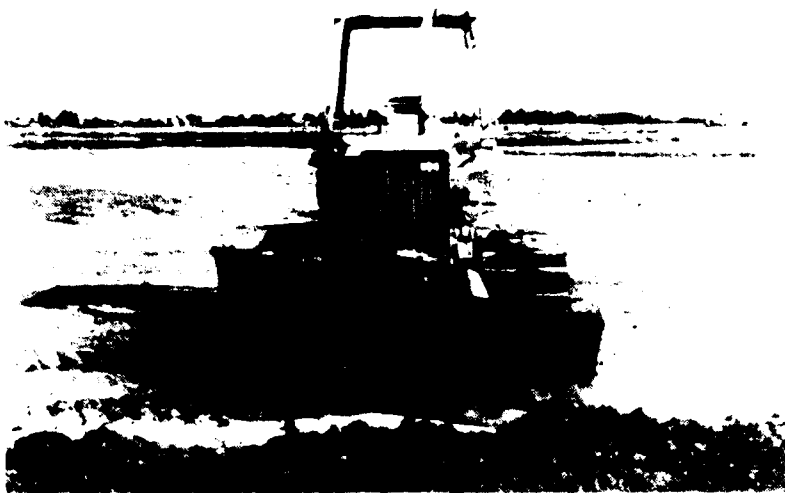
SHELTER CONSTRUCTION/UPGRADING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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DITCHING & REEMING



Equipment

grader
end loader
ditch diggers
scrapers
trucks
backhoes
tractors

RESOURCE INVENTORY SHEET

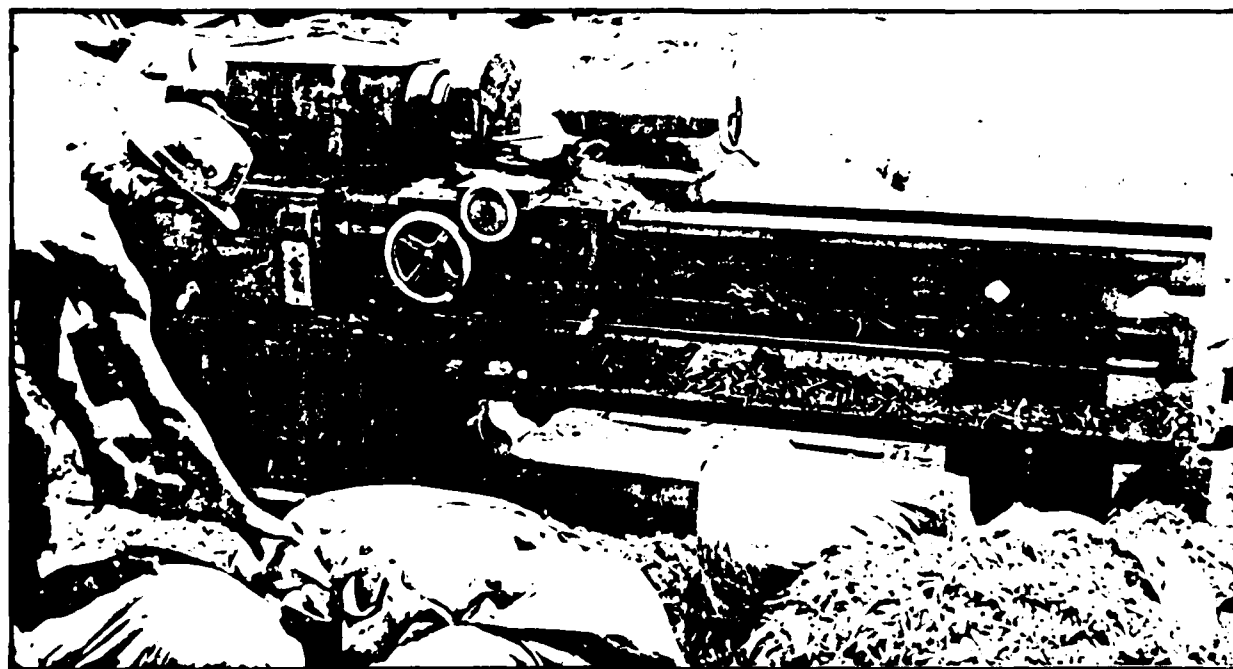
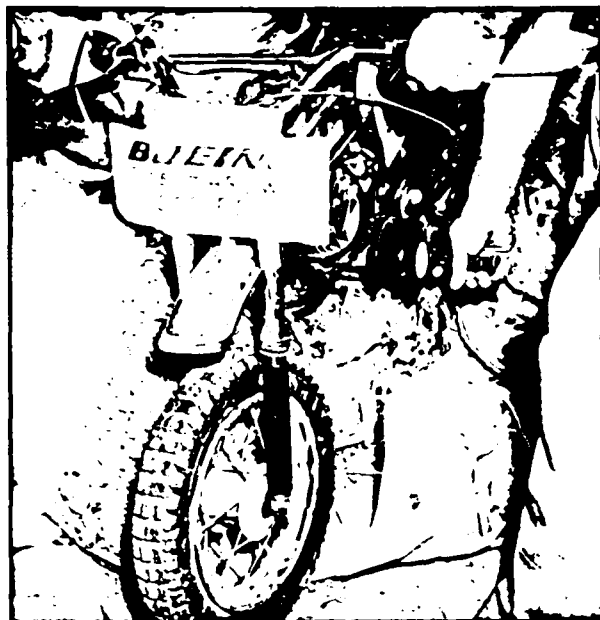
DITCHING & BERMING EQUIPMENT

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



— CRUSHABLE PACKING —

HAY	PAPER
STRAW	CARDBOARD
EXCELSIOR	STYROFOAM
METAL SHAVINGS	FIBERGLAS BATTIS
WOOD CHIPS	PERLITE

— LIGHT COVERING —

MICA	TAR PAPER	NEWSPRINT
MINERAL WOOD	RUGS	LINOLEUM
CORK BOARD	SHEETS	CANVAS
GRAIN	PLASTIC FILM	RUBBER SHEETING
SAWDUST		
TIRBS		

RESOURCE INVENTORY SHEET

CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL

TEAM # _____

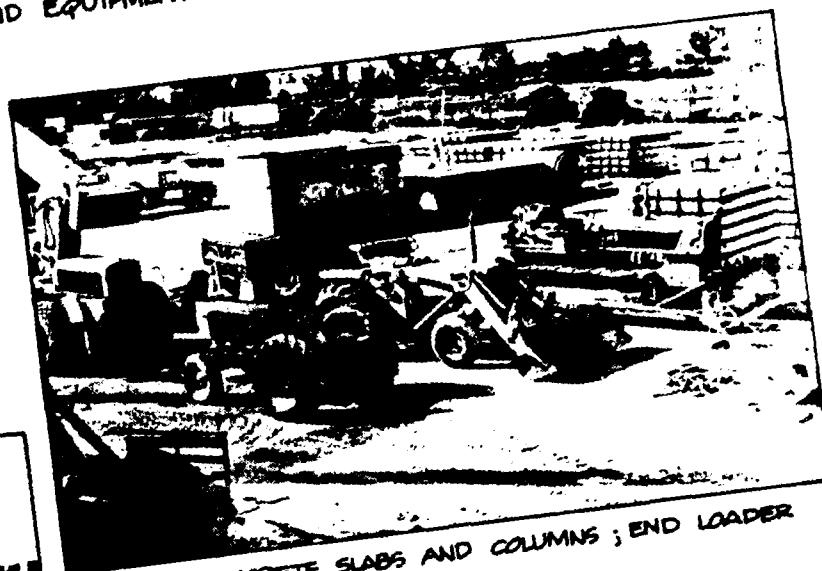
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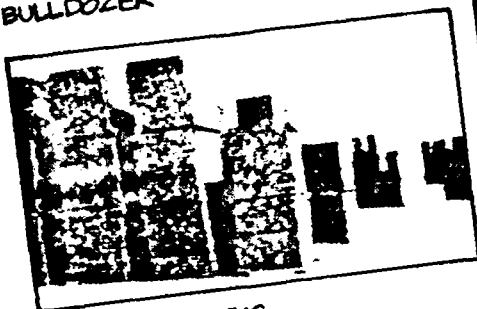
HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



BULLDOZER



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



LUMBER STACKS



Crushable Packing held by
Plastic Sheet Taped in Place

Covered with Dirt using
Conveyor, Truck, and
Backhoe

MATERIALS

DIRT
SAND
GRAVEL
PLYWOOD
LUMBER

CONCRETE SLABS
CONCRETE PIERS
METAL PLATES
BRICK
CONCRETE BLOCK

COAL
RUBBLE
CHAIN LINK FENCE
SAND BAGS
CEMENT SACKS

EQUIPMENT

BULLDOZER
END LOADER
SNOW PLOW
GRADER
TRACTOR

CONVEYOR
FORK LIFT
WITH DEBRIS BOX
DUMPSTER

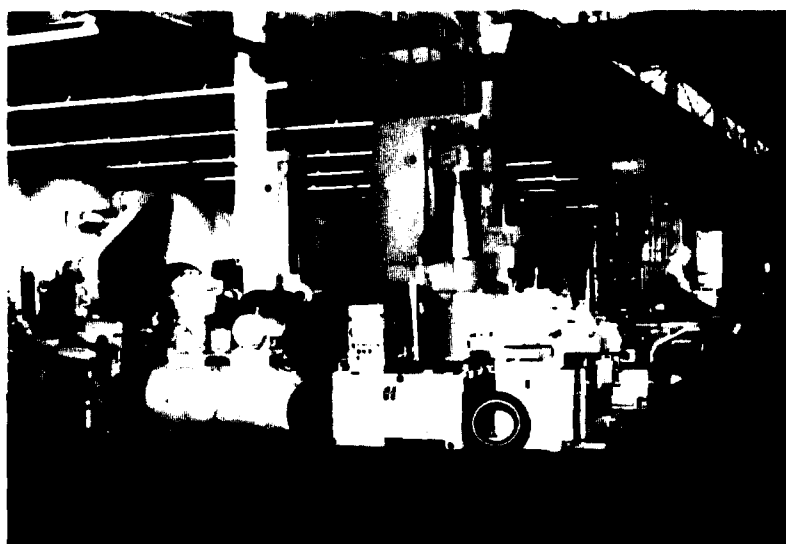
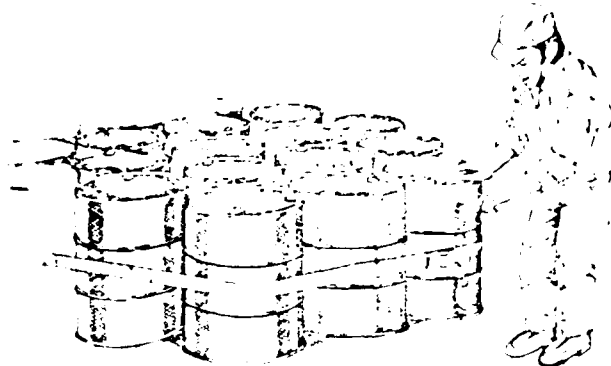
RESOURCE INVENTORY SHEET

HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

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FOR FASTENING AND ANCHORING

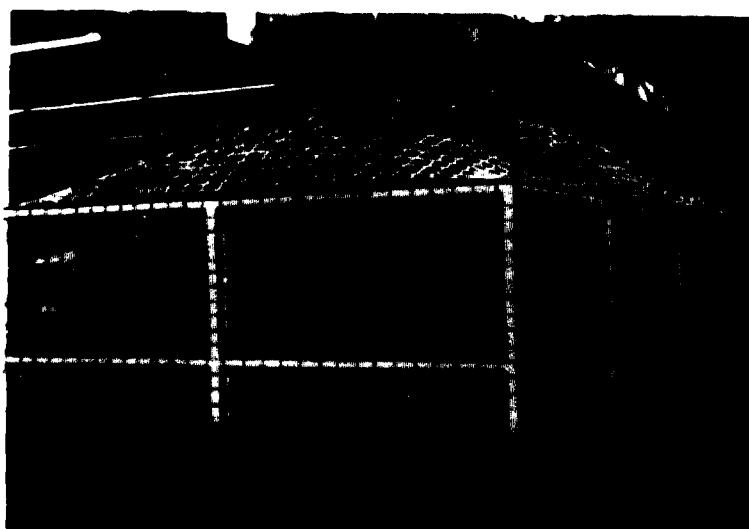


Fastening Materials

wire
cable
trucker strapping
webbing
reinforcing wire
beams and channel
welding rod
chain link fence
cable clamps
turnbuckle

Anchors

pipe
angle iron
rebar
light standards
telephone poles
concrete blocks



RESOURCE INVENTORY SHEET

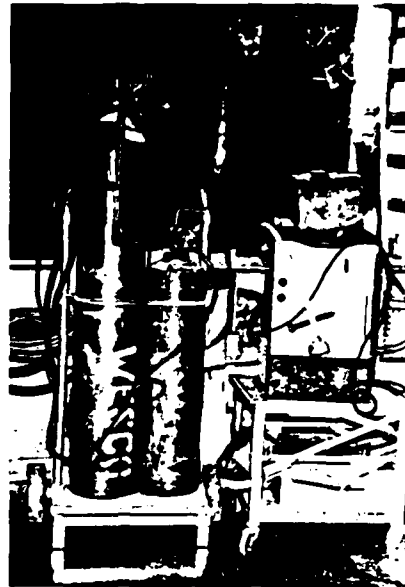
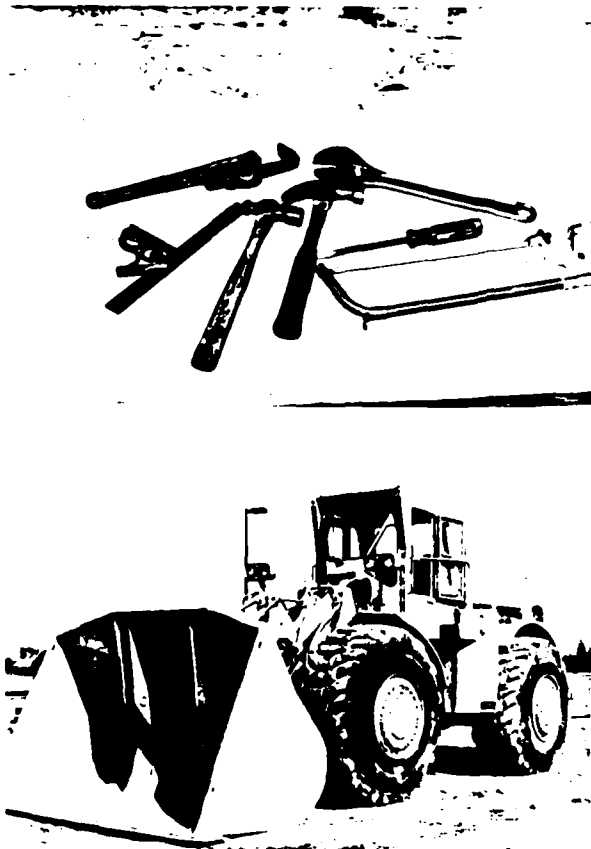
FASTENING & ANCHORING

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RECOVERY



Lifting & Moving Equipment

A-frame
backhoe
end loader
winch
tractor
truck
bulldozer

Maintenance & Repair

welder
torch
hand torch
machine tools
hand tools
equipment manual
repair manual
grinder
generator

Safety

radiac equipment
disposable work clothes
mobile pump units
water tankers
ditching equipment

RESOURCE INVENTORY SHEET

RECOVERY

TEAM #

AREA CODE (IF USED) SHEET #

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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13		
14		

FOR LIFTING, MOVING, TRANSPORTATION



Highway

stake truck
flat bed
U-haul trailer
van
tanker
dump truck
cement truck
dumpster

Rail

flatcar
boxcar
hopper car
tank car

Waterways

barge
garbage scow
raft
ferry



In Plant

crane
gantry
forklift
endloader
cherry picker
jacks
bridge crane
rollers

RESOURCE INVENTORY SHEET

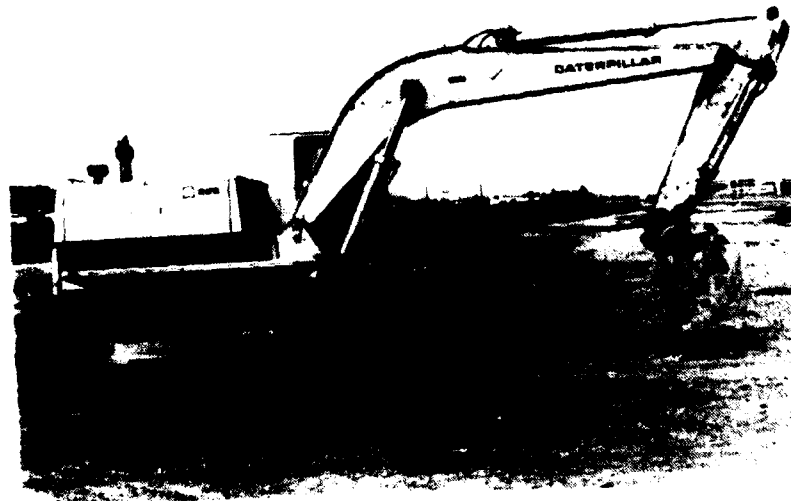
FOR LIFTING, MOVING, TRANSPORTING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

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SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel
conveyor
wheelbarrow
endloader
grader
backhoe
tractor
picks
saws

hammer
sledge
axe
generator
batteries
pumps
blower
A-frames
winches

Materials

nails
plywood
lumber
railway ties
pipe
concrete block
precast concrete

RESOURCE INVENTORY SHEET

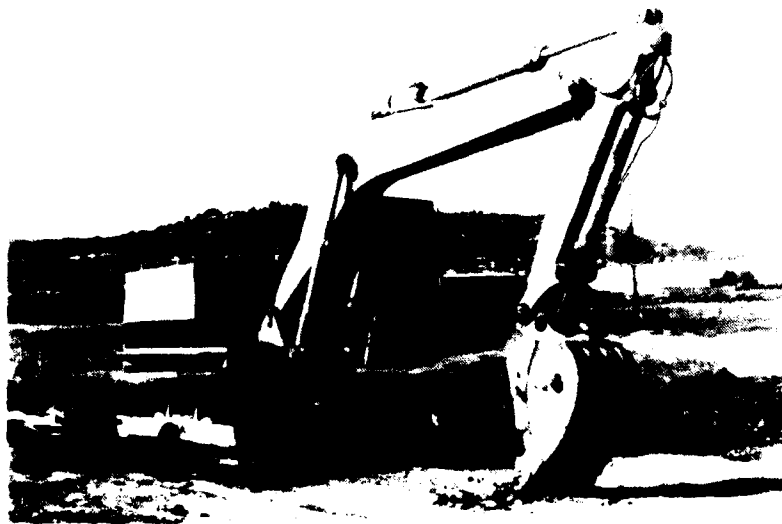
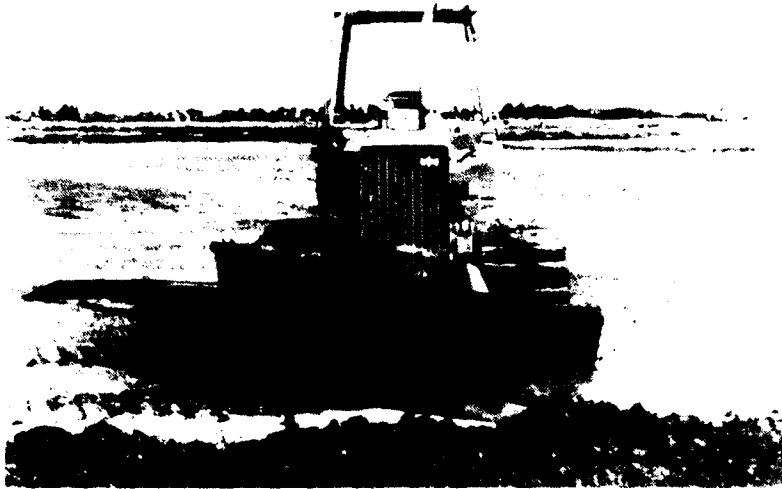
SHELTER CONSTRUCTION/UPGRADING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

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DITCHING & BERMING



Equipment
grader
end loader
fit chd logers
craper
trucks
backhoes
tractors

RESOURCE INVENTORY SHEET

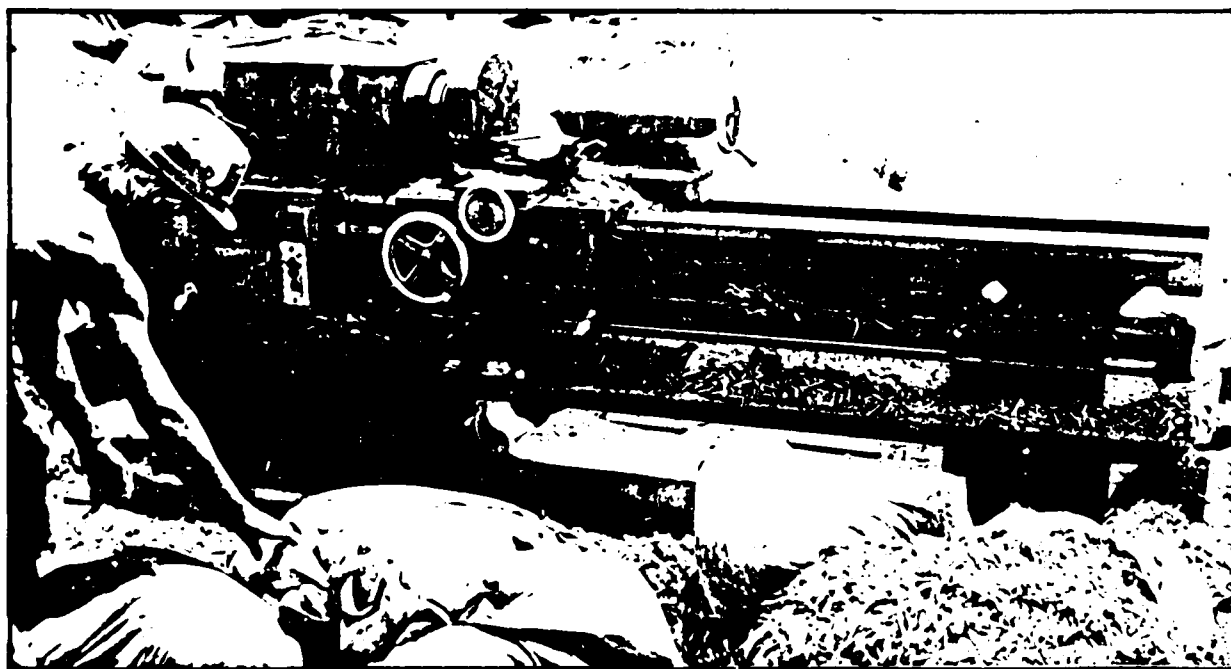
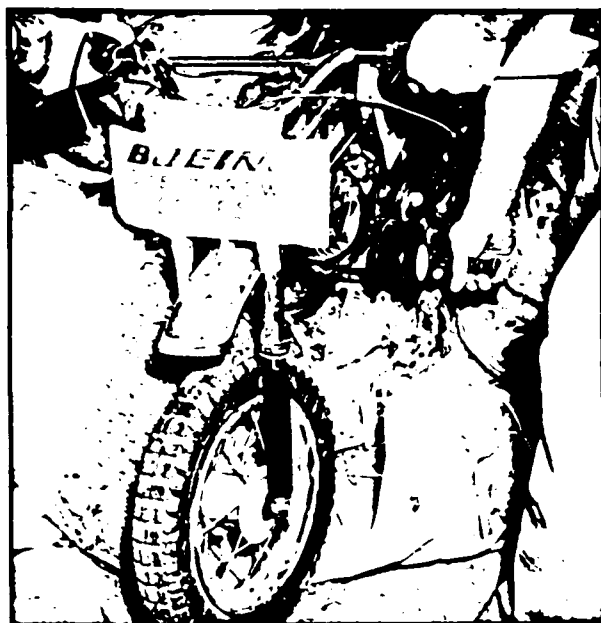
DITCHING & BERMING EQUIPMENT

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



— CRUSHABLE PACKING —

HAY	PAPER
STRAW	CARDBOARD
EXCELSIOR	STYROFOAM
METAL SHAVINGS	FIBERGLAS BATTS
WOOD CHIPS	PERLITE

— LIGHT COVERING —

MICA	TAR PAPER	NEWSPRINT
MINERAL WOOD	RUGS	LINOLEUM
CORK BOARD	SHEETS	CANVAS
GRAIN	PLASTIC FILM	RUBBER SHEETING
SAWDUST		
TIRBS		

RESOURCE INVENTORY SHEET

CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL

TEAM # _____

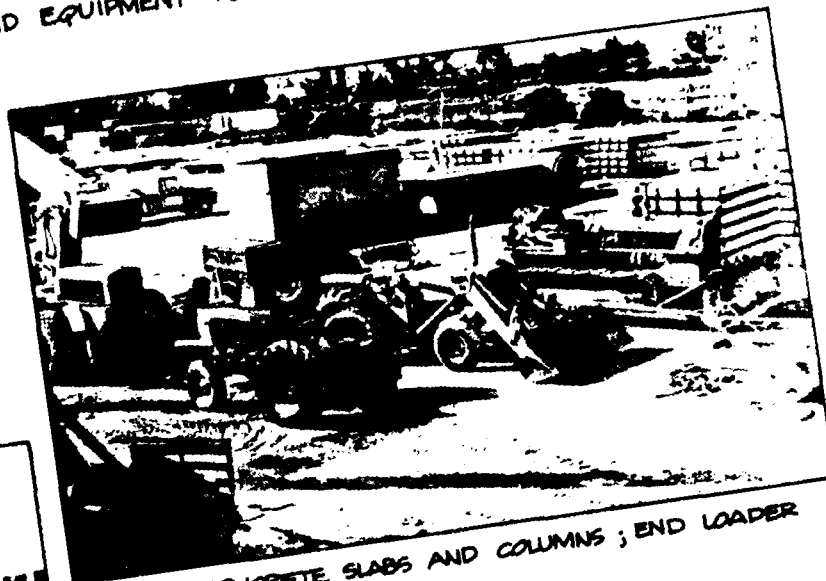
AREA _____ CODE (IF USED) _____ SHEET # _____

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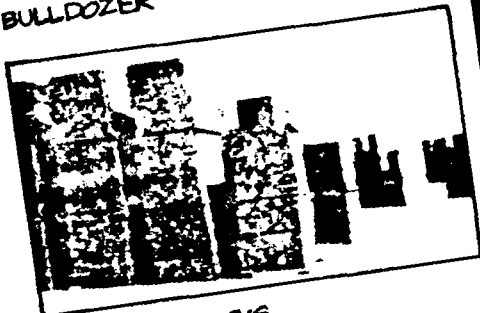
HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



BULLDOZER



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



LUMBER STACKS



Crushable Packing held by
Plastic Sheet Taped in Place

Covered with Dirt using
Conveyor, Truck, and
Backhoe

MATERIALS

DIRT
SAND
GRAVEL
PLYWOOD
LUMBER

CONCRETE SLABS
CONCRETE PIERS
METAL PLATES
BRICK
CONCRETE BLOCK

COAL
RUBBLE
CHAIN LINK FENCE
SAND BAGS
CEMENT SACKS

EQUIPMENT

BULLDOZER
END LOADER
SNOW PLOW
GRADER
TRACTOR

CONVEYOR
FORK LIFT
WITH DEBRIS BOX
DUMPSTER

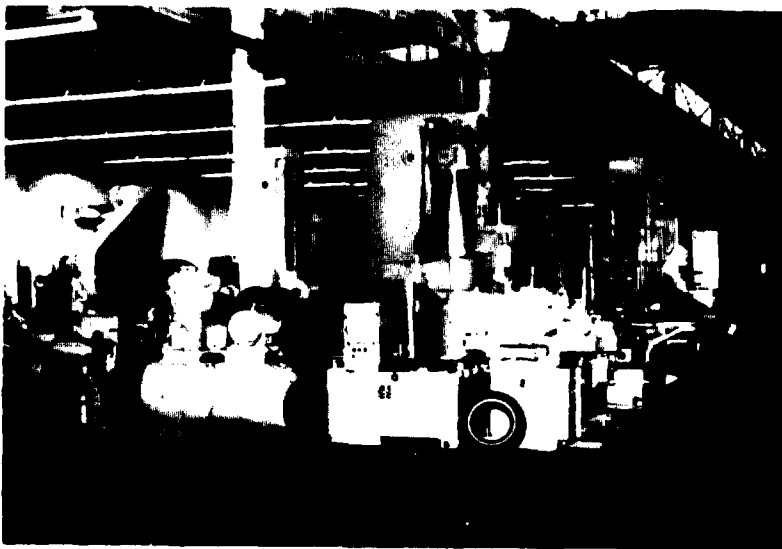
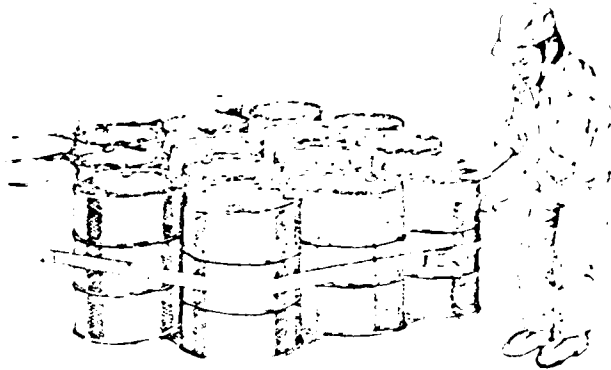
RESOURCE INVENTORY SHEET

HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM # _____

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FOR FASTENING AND ANCHORING

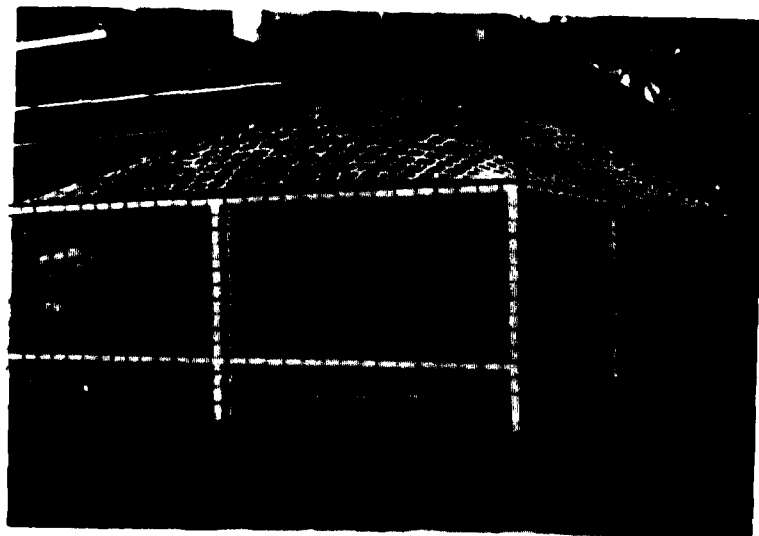


Fastening Materials

wire
cable
trucker strapping
webbing
reinforcing wire
beams and channel
welding rod
chain link fence
cable clamps
turnbuckle

Anchors

pipe
angle iron
rebar
light standards
telephone poles
concrete blocks



RESOURCE INVENTORY SHEET

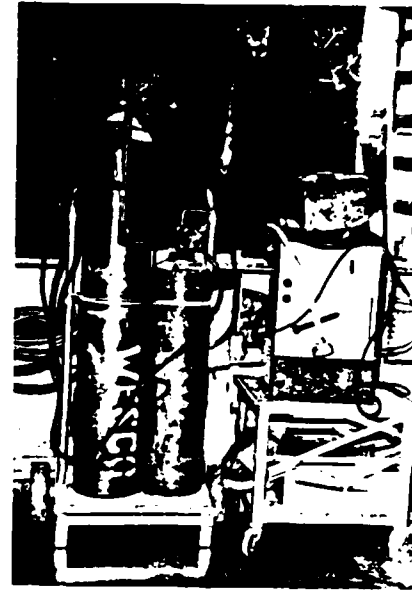
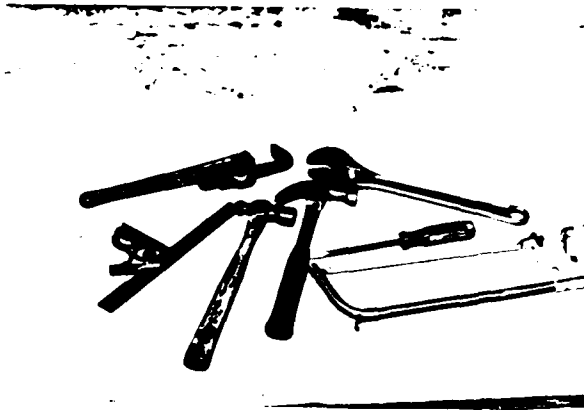
FASTENING & ANCHORING

TEAM # _____

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RECOVERY



Lifting & Moving Equipment

A-frame
backhoe
end loader
winch
tractor
truck
bulldozer

Maintenance & Repair

welder
torch
hand torch
machine tools
hand tools
equipment manual
repair manual
grinder
generator

Safety

radiac equipment
disposable work clothes
mobile pump units
water tankers
ditching equipment

RESOURCE INVENTORY SHEET

RECOVERY

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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FOR LIFTING, MOVING, TRANSPORTATION



Highway

stake truck
flat bed
U-haul trailer
van
tanker
dump truck
cement truck
dumpster

Rail

flatcar
boxcar
hopper car
tank car

Waterways

large
garbage scow
raft
ferry



In Plant

crane
gantry
forklift
endloader
cherry picker
jacks
bridge crane
rollers

RESOURCE INVENTORY SHEET

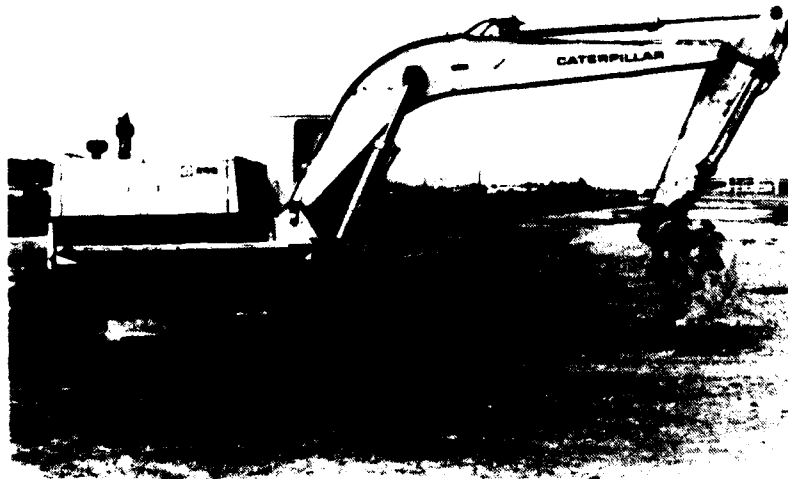
FOR LIFTING, MOVING, TRANSPORTING

TEAM # _____

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SHELTER CONSTRUCTION/UPGRADING



Equipment

shovel
conveyor
wheelbarrow
endloader
grader
backhoe
tractor
picks
saws

hammer
sledge
axe
generator
batteries
pumps
blower
A-frames
winches

Materials

nails
plywood
lumber
railway ties
pipe
concrete block
precast concrete

RESOURCE INVENTORY SHEET

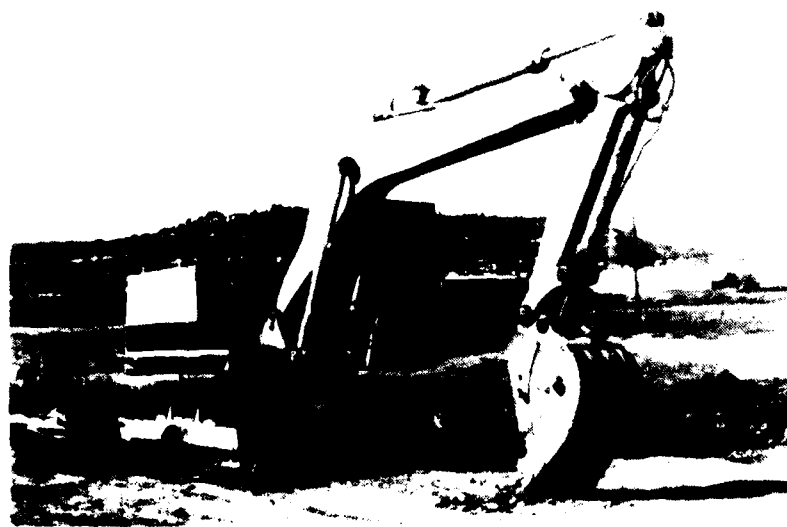
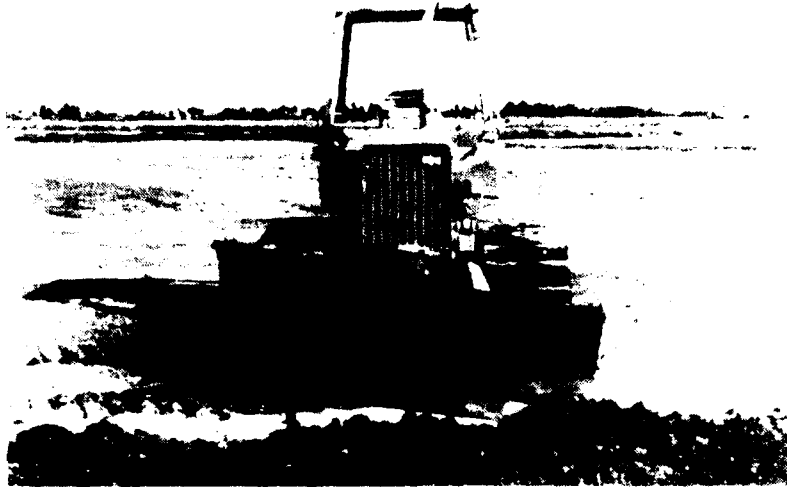
SHELTER CONSTRUCTION/UPGRADING

TEAM # _____

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DITCHING & BERMING



Equipment
grader
end loader
ditch diggers
scraper
trucks
backhoes
tractors

RESOURCE INVENTORY SHEET

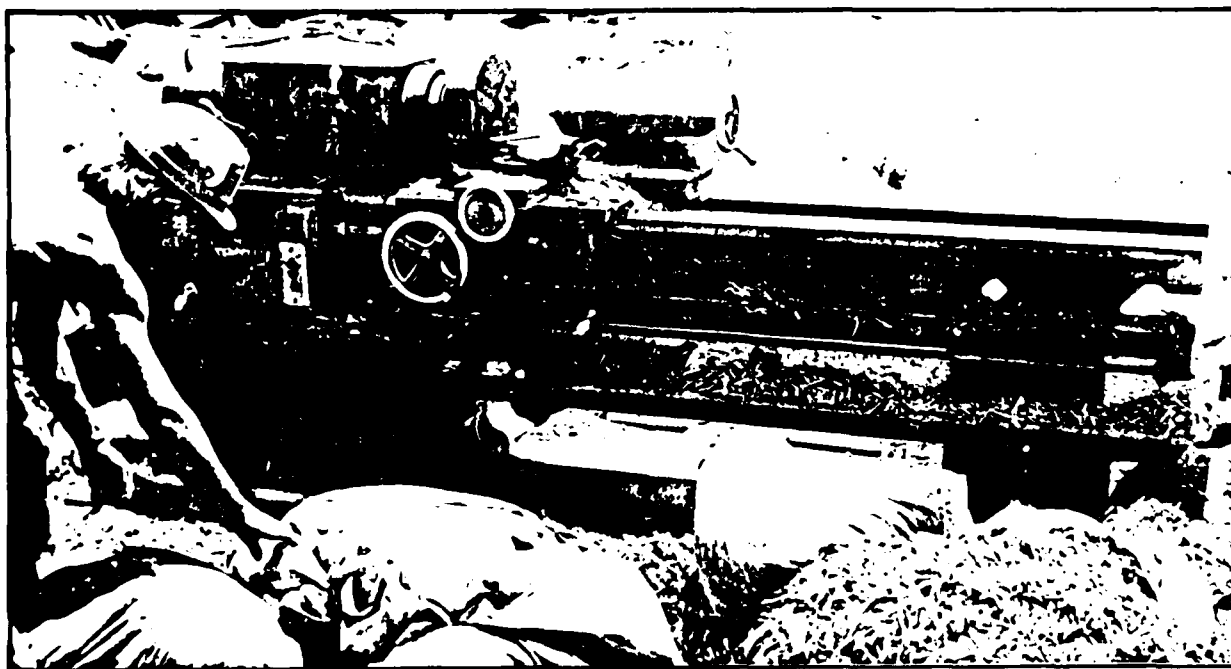
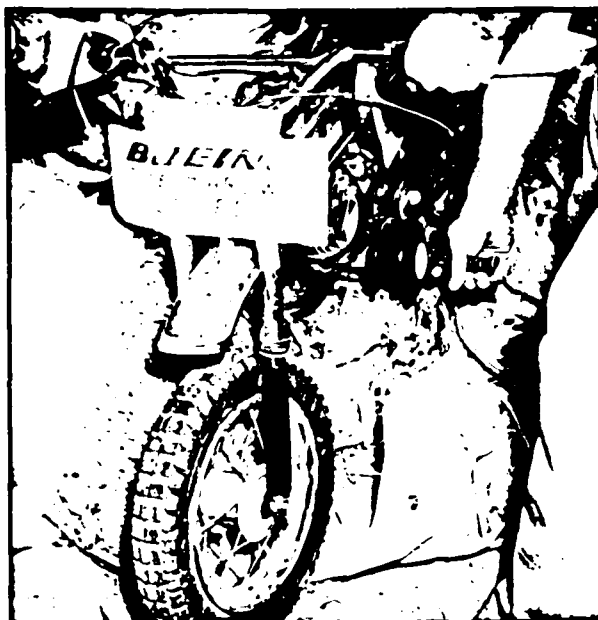
DITCHING & BERMING EQUIPMENT

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

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CRUSHABLE PACKING MATERIAL AND LIGHT COVERING MATERIAL



— CRUSHABLE PACKING —

HAY	PAPER
STRAW	CARDBOARD
EXCELSIOR	STYROFORM
METAL SHAVINGS	FIBERGLAS BATTIS
WOOD CHIPS	PERLITE

— LIGHT COVERING —

MICA	TAR PAPER	NEWSPRINT
MINERAL WOOD	RUGS	LINOLEUM
CORK BOARD	SHEETS	CANVAS
GRAIN	PLASTIC FILM	RUBBER SHEETING
SAWDUST		
TIRBS		

RESOURCE INVENTORY SHEET

CRUSHABLE MATERIALS & LIGHT COVERING MATERIAL

TEAM # _____

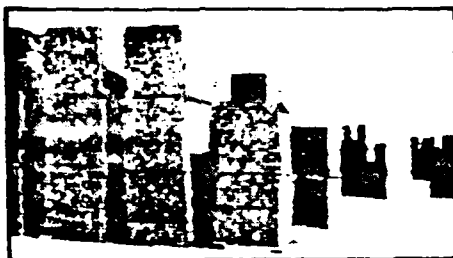
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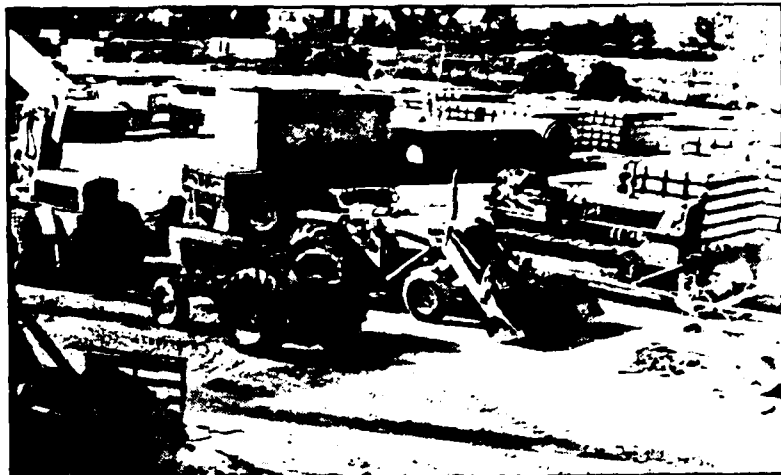
HEAVY DUTY MATERIALS AND EQUIPMENT FOR COVERING AND BURYING



BULLDOZER



LUMBER STACKS



PRECAST CONCRETE SLABS AND COLUMNS ; END LOADER



MATERIALS

DIRT
SAND
GRAVEL
PLYWOOD
LUMBER
CONCRETE SLABS
CONCRETE PIERS
METAL PLATES
BRICK
CONCRETE BLOCK

COAL
RUBBLE
CHAIN LINK FENCE
SAND BAGS
CEMENT SACKS

EQUIPMENT

BULLDOZER
END LOADER
SNOW PLOW
GRADER
TRACTOR
CONVEYOR
FORK LIFT
WITH DEBRIS BOX
DUMPSTER

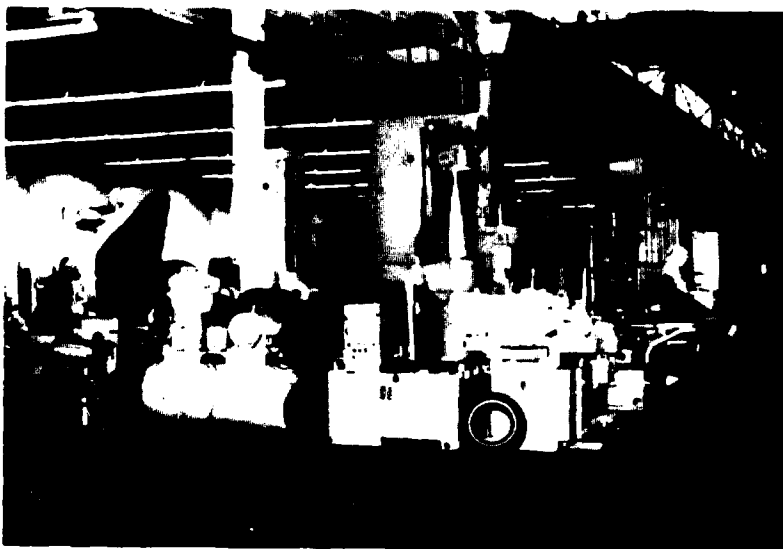
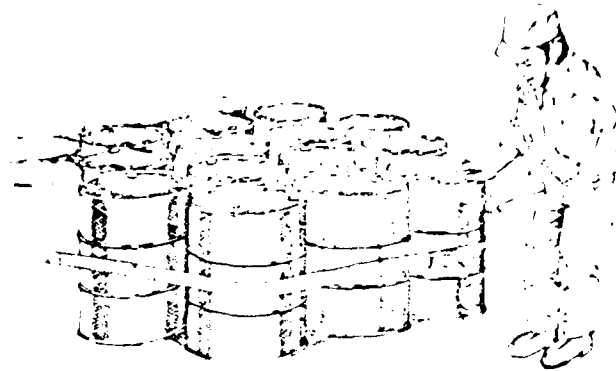
RESOURCE INVENTORY SHEET

HEAVY DUTY MATERIALS & EQUIPMENT FOR COVERING & BURYING TEAM # _____

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FOR FASTENING AND ANCHORING

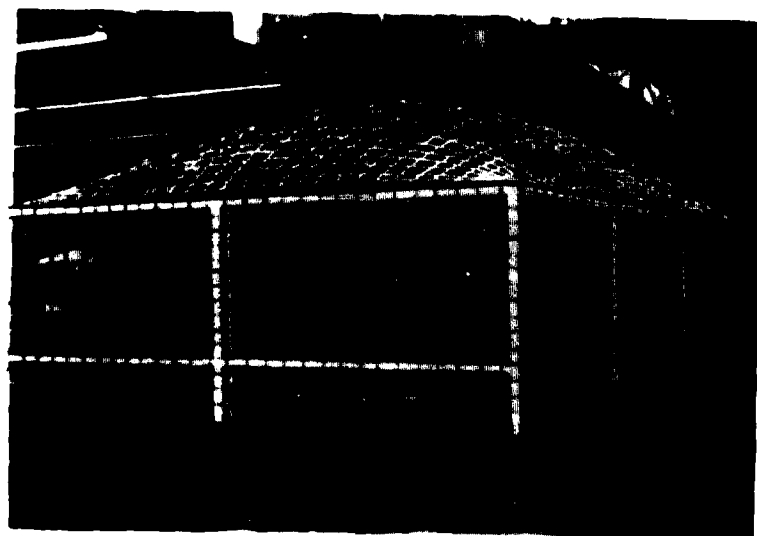


Fastening Materials

wire
cable
trucker strapping
webbing
reinforcing wire
beams and channel
welding rod
chain link fence
cable clamps
turnbuckle

Anchors

pipe
angle iron
rebar
light standards
telephone poles
concrete blocks



RESOURCE INVENTORY SHEET

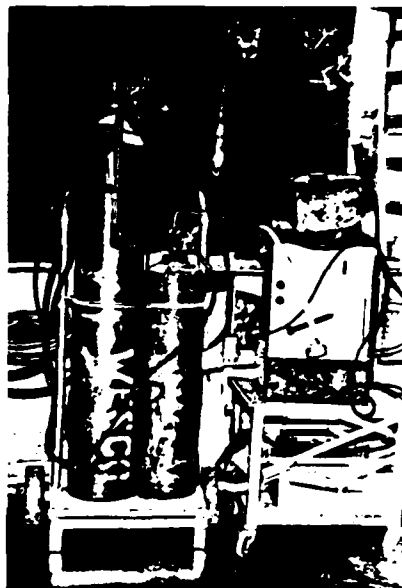
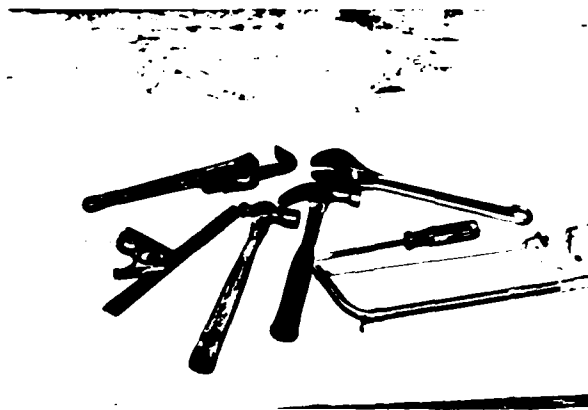
FASTENING & ANCHORING

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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11	_____	_____
12	_____	_____
13	_____	_____
14	_____	_____

RECOVERY



Lifting & Moving Equipment

A-frame
backhoe
end loader
winch
tractor
truck
bulldozer

Maintenance & Repair

welder
torch
hand torch
machine tools
hand tools
equipment manual
repair manual
grinder
generator

Safety

radiac equipment
disposable work clothes
mobile pump units
water tankers
ditching equipment

RESOURCE INVENTORY SHEET

RECOVERY

TEAM # _____

AREA _____ CODE (IF USED) _____ SHEET # _____

ITEM #	DESCRIPTION & LOCATION	QUANTITY
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INDUSTRIAL

PROTECTION

GUIDE

**CRISIS RELOCATION
INDUSTRIAL HARDENING PLAN**

**EQUIPMENT
INVENTORY**

BOOKLET 6

SCIENTIFIC SERVICE, INC.

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 6

EQUIPMENT INVENTORY

This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

Booklet 6
EQUIPMENT INVENTORY

Coordinator: _____
(name)

Alternate: _____
(name)

Objective: To arrive at an equipment list that is rated according to each item's relative importance to production, so that a decision can be made as to whether to protect it very well, scarcely at all, move it, etc.

This booklet is part of a plan to protect industrial plant equipment from possible damage in the event of a major disaster. It will enable you to develop a list of plant equipment organized to establish hardening priorities. There may be a limit to the plant equipment that you will be able to protect with the time, materials, equipment, and personnel available, so you may have to make some hard choices. There are a number of approaches that can simplify this task. For example, suppose there is a great deal of duplication in production equipment and processes at your plant. If that is the case, you could start hardening just part of this equipment. For example, consider a single shift production line including 1 lathe, 4 punch presses, 6 drill presses, and 2 riveting machines. You could immediately evacuate or harden the lathe and one combination of 2 punch presses, 3 drill presses, and 1 riveting machine -- then, if time and resources permit, harden the other (duplicate) set. If there is so little duplication (or you already operate three shifts) that this option is not really practical -- and you are faced with insufficient time, materials, or personnel to harden everything -- then you should consider alternative methods of production that require less equipment. You may be able to salvage enough equipment to return to this alternative production method with fewer production penalties. Should neither of these two approaches work, another method has been provided in Booklets 6 through 8.

When the inventory is completed, give the forms to the Hardening Operations Manager.

INSTRUCTIONS FOR COORDINATOR

You will be assembling a crew to compile a complete list of plant equipment (see sample form at the beginning of the worksheets). This list will be used by the Hardening Operations Manager to decide priorities for protecting equipment according to methods identified in Booklet 9. After you examine this booklet and the inventory form, you should look at the hardening options in Booklet 9.

When your crew compiles the inventory, management will require additional information -- for example, mounting data, size, weight, and general mobility -- because equipment to be moved must be readily disconnected, manageable with onsite materials handling equipment, and sized to fit on trucks, barges, flatcars, trailers, etc., and/or wherever it is to go. Where equipment is duplicated, number the items in sequence during inventory from best to worst to show the order for hardening attention. (This may require your maintenance engineer to identify the best units to save.)

Read through booklet, then provide an estimate of your personnel needs to management so you can complete the task.

Organize your crew into teams so all plant areas can be covered, rapidly.

- o Use one or two men to a team.
- o Assign specific areas of the plant to each survey team.

Example — Team 1: Outside areas.
Team 2: Bays 1 and 2 of building A.
Team 3: First through 4th floors of
 building B.
Team 4: Process line No. 4.

Reproduce and distribute inventory books to each team (make certain that enough forms are available).

If you have waited until the evacuation order, arrange to have completed inventory sheets returned to you (in exchange for another blank) as each sheet is finished. (Use second member of team, or establish a special messenger squad to circulate and exchange blank forms for completed ones.) To expedite the next stage, give completed forms to the Hardening Operations Manager as they are collected.

It may be faster to use existing knowledge or records of equipment (i.e., inventory data, or plant layout drawings) where readily available, and have teams recheck data by actual inspection as they enter additional information required.

SCHEDULE

Tasks	Time Line (elapsed)
Organize teams (1 to 2 men maximum)	0 to 15 min
Pass out inventory sheets	
Review the instructions (starting on page 5) with team members.	
Team Members:	
Fill out inventory sheets provided each team	15 min to 1 hr
Return sheets to Coordinator.	
Coordinator:	
Review team progress and reassign areas as required	20 min to 1 hr
Review inventory sheets, revise and correct as required.	
Release team members to labor pool to be reassigned.	1 hr
Turn in inventory sheets to Vulnerability and Priority Rating team (Booklet 7 Coordinator) as the sheets are completed	20 min to 1 hr

INSTRUCTIONS FOR TEAM MEMBERS

Instructions on how to fill out equipment inventory sheets are as follows (see example sheet at the beginning of the worksheets):

STEP 1: Enter general location of equipment and page number at the top of each page, identify team.

STEP 2: Itemize equipment* name and description (quantity, size).

DO -- o Provide a complete list of plant equipment (fixed, installed, movable or mobile)

o List identical equipment as one line item where possible

Example: Drill presses (6 standing, 4 bench)

o Then tag each with a number to show the next crew which unit to save first (best remaining unit until time or resources run out)

o Provide approximate width, depth, height and weight data on all equipment essential to production.

* The final objective is to arrive at an equipment list that is rated according to each item's relative importance to production, so that a decision can be made as to whether to protect it very well, scarcely at all, move it, etc.

DON'T -- o Do not list parts of a single piece of equipment as separate items unless they are mounted separately.

Example: Do not list "electric motor mounted on drill press"; just list drill press.

o Do not list process line equipment as a single item.

Example: Do not list "tomato press line"; instead, break down into operational components so relative importance of items in the line will be determined.

STEP 3: Under "Remarks" list:

- o Mounting information: Not secured; bolted to concrete floor, wall; number and size of bolts, time to remove them; hard-wired (H) or quick-disconnect (Q.D.) power input.
- o Indicate whether it is (U) unmovable¹, (M) movable², (D) difficult to move³.

STEP 4: List under "SD Time" how long it will take to shut down that equipment, if operating.

- o If already shut down, enter "O";
- o If management indicates the equipment is to continue operating throughout the crisis period, enter an "X" in "SD time".

1. Requires outside mover and equipment, or cannot be moved at all.

2. Easily moved in minutes to one hour without tying up major materials handling equipment.

3. Movable in a period of several hours, tying up or taxing available cranes, etc.

STEP 5: Establish and record the essential rating of the equipment. Record one of the following Ratings in the "E" column of the inventory form.

"E" Rating

Description

- 1 **Absolutely Essential** --- Equipment required to operate during the crisis period to ensure survival supplies for the population. If more than one unit, harden half of units and operate the other half through crisis. If only one unit, shut down and harden, so it will be available post-crisis. (If it is important to survival during the crisis, it should be more important to survival after it.)
- 2 **Essential to the Process** --- Equipment that is a key to some step in the production process which would stop all regular production immediately if it were eliminated, but would not make it impossible to jury rig an alternative process with lower output. (One of a kind for current production level, but do-able via alternative process.)
- 3 **Essential for Normal Operations** --- Equipment that is required principally for normal operation of the plant, but for which there are several of a kind with production rate affected by numbers available.
- 4 **Non-Essential** --- Safety and pollution equipment, and backup equipment used only for occasional peak demand periods.

STEP 6: Establish and record an equipment replacement/repair rating. This rating is not for normal operational repair, but rather repair after something like an earthquake overturning the piece of equipment or the building falling on it. Record one of the following replacement/repair ratings in the "RR" column of the inventory form.

"RR" Rating	Description
1	Impossible --- refers to those items not repairable without new parts from outside, and outside help.
2	Difficult --- includes those items that would be better sent outside for repair or replacement work, but might be replaced or repaired with some difficulty by inplant personnel using materials and equipment on hand.
3	Possible ---- includes those items that could be repaired by inhouse personnel without too much difficulty using materials and equipment on hand.
4	Easy ---- refers to items for which many spares or substitute parts are commonly available both onsite and off and which can be repaired with resources on hand, or by simply jury rigging common materials.

Essential ratings and Replacement/Repair ratings are summarized on the back of the page facing the worksheets.

W O R K S H E E T S

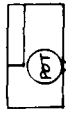
ESSENTIAL RATINGS

Rating	Description
1	Absolutely Essential ---- Equipment required to <u>operate</u> during the crisis period to <u>ensure</u> survival supplies for the population. If more than one unit, harden half of units and operate the other half through crisis. If only one unit, shut down and harden, so it will be available post-crisis. (If it is important to survival during the crisis, it should be more important to survival after it.)
2	Essential to the Process ---- Equipment that is a key to some step in the production process which would stop all regular production immediately if it were eliminated, but would not make it impossible to jury rig an alternative process with lower output. (One of a kind for current production level, but do-able via alternative process.)
3	Essential for Normal Operations ---- Equipment that is required principally for normal operation of the plant, but for which there are several of a kind with production rate affected by numbers available.
4	Non-Essential ---- Safety and pollution equipment, and backup equipment used only for occasional peak demand periods.

Each inventory sheet should be used for one area only. If you start to inventory another area -- start another worksheet. Turn in sheets as they are completed to coordinator.

REPLACEMENT/REPAIR RATINGS

Rating	Description
1	Impossible ---- refers to those items not repairable without new parts from outside, and outside help.
2	Difficult ---- includes those items that would be better sent outside for repair or replacement work, but might be replaced or repaired with some difficulty by inplant personnel using materials and equipment on hand.
3	Possible ---- includes those items that could be repaired by inhouse personnel without too much difficulty using materials and equipment on hand.
4	Easy ---- refers to items for which many spares or substitute parts are commonly available both onsite and off and which can be repaired with resources on hand, or by simply jury rigging common materials.

ALDO AREA		B FLR 5		EQUIPMENT INVENTORY WORKSHEET		SQUAD MEMBERS		PAGE	
						NAME/UR/UF		#	
ITEM NO	EQUIPMENT NAME AND DESCRIPTION	QTY	SIZE	REMARKS	START DOWN TIME	E	EX		
1	AIR COMPRESSORS # 1 AND # 2 650 CFM WATER-COOLED 125 HP 240V	2	H 10 FT W 5 FT L 8 FT DIA	ONE HORIZONTAL AND ONE VERTICAL CYLINDER IN L-SHAPE DESIGN 5/8" BOLTS TO FLOOR	0	2	2		
2	AIR COMPRESSORS # 3, 4, AND 5 155 CFM 40 HP, 240V WATER-COOLED	3	H 4 FT W 4 FT L 12 FT DIA	HORIZONTAL SINGLE-STAGE HEAVY CASTINGS BOLTED TO CONCRETE PAD WITH 1/2" BOLTS NARROW BASE	0	3	2		
3	AIR RECEIVER, PRESSURE TANK FOR PLANT AIR SUPPLY TWO 5" AIR LINES, 1/2" DRAIN TWO GAUGES	1	H 12 FT W L DIA 5 FT	ASME PRESSURE VESSEL WITH VERTICAL ORIENTATION BOLTED TO CONCRETE PAD WITH 4 1/2" BOLTS	0	3	3		
4	MILLING MACHINE CINCINNATI MILACRON	1	H 6 FT W 4 FT L 6 FT DIA	VERTICAL MILL HEAVY CASTINGS BOLTED TO CONCRETE FLOOR WITH 3/8" BOLTS	0	2	3		
5	AIR HOIST, PISTON-TYPE WIRE ROPE EQUIPPED 4,000 LBS CAPACITY	12	H W L 3 FT DIA 1 1/2 IN	HUNG ON BRIDGE CRANES WITH ONE 3/8" BOLT	0	3	3		
6	AIR POLLUTION BAGHOUSE PULSE-AIR TYPE WITH 750 BAGS 10,000 CFM, 3 COMPARTMENTS	1	H 15 FT W 10 FT L 16 FT DIA	LIGHT GAUGE METAL WALLS, METAL STRUCTURE 3" X 3" X 1/4" ANGLE-IRON BOLTED TO CONCRETE PAD WITH 5/8" BOLTS AT 8 PLACES	0	4	4		
7	ELECTRIC FURNACE 100 KW, 480V 400 CYCLE 	1	H 5 FT W 10 FT L 8 FT DIA 3 FT	BOLT ON TRUNNIONS HEAVY STEEL SHELL LINED WITH REFRACTORY CONTROL CONSOLE 4' X 3' STEEL DECK OVER 10' DEEP CONCRETE PIT	3 HOURS	2	2		
<p>COULD ANY STRUCTURE FALL ON EQUIPMENT IF IT FELL IN THE DIRECTION OF THE EQUIPMENT?</p> <p>METAL FRAMED BUILDING WITH 100% WINDOW AREA METAL SIDING - NORTH WALL CONCRETE BLOCK SEVERE MISSILE PROBLEMS WITH BOTH</p>									

* USE THE BACK OF THIS WORKSHEET FOR SKETCHES SHOWING EQUIPMENT LOCATION IF DESIRED

EXAMPLE SHEET

ESSENTIAL RATINGS

Rating

Description

- 1 **Absolutely Essential** --- Equipment required to operate during the crisis period to ensure survival supplies for the population. If more than one unit, harden half of units and operate the other half through crisis. If only one unit, shut down and harden, so it will be available post-crisis. (If it is important to survival during the crisis, it should be more important to survival after it.)
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- 4 **Non-Essential** --- Safety and pollution equipment, and backup equipment used only for occasional peak demand periods.

Each inventory sheet should be used for one area only. If you start to inventory another area -- start another worksheet. Turn in sheets as they are completed to coordinator.

REPLACEMENT/REPAIR RATINGS

Rating

Description

- 1 **Impossible** --- refers to those items not repairable without new parts from outside, and outside help.
- 2 **Difficult** --- includes those items that would be better sent outside for repair or replacement work, but might be replaced or repaired with some difficulty by inplant personnel using materials and equipment on hand.
- 3 **Possible** --- includes those items that could be repaired by inhouse personnel without too much difficulty using materials and equipment on hand.
- 4 **Easy** --- refers to items for which many spares or substitute parts are commonly available both onsite and off and which can be repaired with resources on hand, or by simply jury rigging common materials.

ITEM N°	EQUIPMENT NAME AND DESCRIPTION	QTY	SIZE	REMARKS	SHUT DOWN TIME	E	RR
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* USE THE BACK OF THIS WORKSHEET FOR SKETCHES SHOWING EQUIPMENT LOCATION & DIRECTION

ITEM N°	EQUIPMENT NAME AND DESCRIPTION	QTY	SIZE	REMARKS	SHUT DOWN TIME	E	RR
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* IF THE BACK OF THIS WORKSHEET FOR SKETCHES SHOWING EQUIPMENT LOCATION, IT DESIGNED

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* USE THE BACK OF THIS WORKSHEET FOR SKETCHES SHOWING EQUIPMENT LOCATION, IF DESIRED

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SQUAD NUMBERS

EQUIPMENT LOCATION

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U.S. DEPARTMENT OF AGRICULTURE

111

[illegible]

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Figure 1. The effect of the number of trials on the number of correct responses. The number of correct responses (Y-axis) is plotted against the number of trials (X-axis). The data shows a positive correlation between the number of trials and the number of correct responses, with a slight increase in the number of correct responses as the number of trials increases.

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APPROVED FOR

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Figure 1 is a line graph showing the percentage of total catch versus the number of hauls for three species: *P. setiferus*, *P. setiferus* + *P. setiferus* + *P. setiferus*, and *P. setiferus* + *P. setiferus* + *P. setiferus*. The x-axis represents the number of hauls (1 to 10), and the y-axis represents the percentage of total catch (0 to 100). The graph shows that the percentage of total catch increases with the number of hauls, with *P. setiferus* + *P. setiferus* + *P. setiferus* showing the highest percentage of total catch.

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COULD ANY STRUCTURE FALL ON EQUIPMENT IF IT FELL. IN THE DIRECTION OF THE EQUIPMENT?

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3	10:10	ALL SQUADS REPORT	PP
4	10:15	ALL SQUADS REPORT	PP
5	10:20	ALL SQUADS REPORT	PP
6	10:25	ALL SQUADS REPORT	PP
7	10:30	ALL SQUADS REPORT	PP
8	10:35	ALL SQUADS REPORT	PP
9	10:40	ALL SQUADS REPORT	PP
10	10:45	ALL SQUADS REPORT	PP
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23	11:50	ALL SQUADS REPORT	PP
24	11:55	ALL SQUADS REPORT	PP
25	12:00	ALL SQUADS REPORT	PP

* USE THE BACK OF THIS WORKSHEET FOR SKETCHES SHOWING EQUIPMENT LOCATION. IF DESIRED

COULD ANY STRUCTURE FALL ON EQUIPMENT IF IT FELL IN THE DIRECTION OF THE EQUIPMENT?

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COULD ANY STRUCTURE FALL ON EQUIPMENT IF IT FELL IN THE DIRECTION OF THE EQUIPMENT?

IF THE RISK OF THIS WORKSHEET FOR SKETCHES SHOWING EQUIPMENT LOCATION, DESIRED

INDUSTRIAL

PROTECTION

GUIDE

CRISIS RELOCATION
INDUSTRIAL HARDENING PLAN

VULNERABILITY
&
PRIORITY
RATING
BOOKLET 7

SCIENTIFIC SERVICE, INC.

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 7

VULNERABILITY/PRIORITY RATING & HARDENING DECISIONS

This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

Booklet 7

VULNERABILITY/PRIORITY RATINGS and HARDENING DECISIONS

Hardening Operations Manager: _____
(name)

Alternate _____
(name)

Objective: To determine the relative importance and vulnerability of each item of plant equipment in order to establish priorities (and allocate resources) for hardening.

This booklet is part of the plan to protect equipment from possible damage in the event of a major disaster. It provides approaches to setting hardening priorities. The aim is a methodology to combine systematically, the relative importance to production of each item of equipment and its vulnerability. The combined rating provides a basis for ranking the order in which hardening activities should proceed to deliver the greatest overall reduction in plant vulnerability. It will be based on your assignment of relative importance to operations and on the relative vulnerability of equipment in your plant. Plant personnel assigned to this task should have the ability to recognize alternative production methods that can be used in emergencies to maintain some production when there is damaged or inoperative equipment.

PROCEDURE SUMMARY

A numerical **vulnerability/priority** rating must be determined for each item on the equipment inventory list compiled by the equipment inventory team. The worksheets from this booklet, the completed worksheets from Booklet 6, and Booklet 8 are all required to complete the assignment of vulnerability/priority ratings. This vulnerability/priority rating is a combination of the first item and one or the other of the two remaining items listed below:

- o The essential rating, **E**, and the replacement-repair rating, **RR**, assigned during the equipment inventory. (These ratings are defined on the back of the sample inventory worksheet of Booklet 6 and repeated on page 6, here.)
- o The equipment "Blast" rating obtained from the equipment index and the vulnerability/blast rating catalog, Booklets 8A and 8B.
- o The building "structural" rating, **2**, if equipment is indoors. If equipment is outdoors and within range of **any** structure once it is toppled, the rating **2** should be entered under structural, as well.

VULNERABILITY/PRIORITY RATING INSTRUCTIONS

Using the following procedures, work rapidly to establish priorities (rank) of each piece of equipment for hardening:

- STEP 1: Collect the equipment inventory worksheets from the coordinator and lay them out side by side with the hardening decision worksheets to develop the equipment priority ranking (see page 5).
- STEP 2: Number each hardening decision worksheet to correspond to the inventory sheet (see page 5).
- STEP 3: Add the Essential (E) to the Replacement/Repair (RR) rating and record in column A of the hardening decision worksheet.
- STEP 4: Use the Equipment Index and the Vulnerability/Blast Rating Catalog, Booklets 8A and 8B, to determine the blast rating (survival rating with protective housekeeping) for each piece of equipment and record on the worksheet (column B).

STEP 5: If the equipment is not located in an area where collateral damage* can occur, record "n/a" (not applicable) in column C. If the equipment could be heavily damaged by parts of the building and/or adjacent structures (the assumption is to be made that these fall over), enter "2" in column C.

STEP 6: Take the smaller of the two ratings from column B, "blast", or column C, "structural", and add it to column A, "E + RR", to determine the priority rating (**PR**) of the equipment:

$$\text{PR} = \text{Col. A} + \text{Col. B} \quad \text{or} \quad \text{Col. A} + \text{Col. C} \quad (\text{whichever is lower})$$

Where Col. C is "na", use Col. B.

Record PR value in column marked "Priority" on worksheet.

Once all the priorities are entered, the **lowest** number identifies the weakest link(s) in production equipment that most need to be hardened (see example on page 5). The major hazard to each item will be evident (often the building that houses the equipment).

STEP 7: Redline all items below a priority rating of 8 for immediate attention; then proceed with hardening decisions (see page 7).

* Collateral damage is damage caused by buildings collapsing or toppling over, flying bricks, etc.

ESSENTIAL RATINGS

- | Rating | Description |
|--------|--|
| 1 | Absolutely Essential ---- Equipment required to <u>operate</u> during the crisis period to ensure survival supplies for the population. If more than one unit, harden half of units and operate the other half through crisis. If only one unit, shut down and harden, so it will be available post-crisis. (If it is important to survival during the crisis, it should be more important to survival after it.) |
| 2 | Essential to the Process ---- Equipment that is a key to some step in the production process which would stop all regular production immediately if it were eliminated, but would not make it impossible to jury rig an alternative process with lower output. (One of a kind for current production level, but do-able via alternative process.) |
| 3 | Essential for Normal Operations ---- Equipment that is required principally for normal operation of the plant, but for which there are several of a kind with production rate affected by numbers available. |
| 4 | Non-Essential ---- Safety and pollution equipment, and backup equipment used only for occasional peak demand periods. |

Each inventory sheet should be used for one area only. If you start to inventory another area -- start another worksheet. Turn in sheets as they are completed to coordinator.

REPLACEMENT/REPAIR RATINGS

- | Rating | Description |
|--------|---|
| 1 | Impossible ---- refers to those items not repairable without new parts from outside, and outside help. |
| 2 | Difficult ---- includes those items that would be better sent outside for repair or replacement work, but might be replaced or repaired with some difficulty by inplant personnel using materials and equipment on hand. |
| 3 | Possible ---- includes those items that could be repaired by inhouse personnel without too much difficulty using materials and equipment on hand. |
| 4 | Easy ---- refers to items for which many spares or substitute parts are commonly available both onsite and off and which can be repaired with resources on hand, or by simply jury rigging common materials. |

HARDENING METHOD DECISION PROCESS

1. Review Requirements

- A. Determine the highest priority equipment (that with the lowest numbered priority rating). This should establish a reduced list of equipment that should be hardened first.
- B. Determine the source of equipment damage from the equipment inventory survey (according to equipment location). Damage sources are:
 - (1) Building collapse (impact of heavy walls, floors, roof, building frame)
 - (2) Missiles (impact of wall sheathing, bricks, concrete blocks, etc., from structures)
 - (3) Drag (high winds on unsecured equipment leading to overturning, sliding, and impact)
 - (4) Fire (damage initiated, spread to debris, cutting oils, solvents, etc.)
 - (5) Pressure-caused equipment collapse
 - (6) Electromagnetic pulse (from thermonuclear pulse)

2. Review Resources

- A. Manpower: Estimate the number of personnel available for hardening tasks (Plan to evacuate: 20%, Day 1; 30% more, Day 2; remainder, Day 3).
- B. Equipment, materials, and tools: Review the data obtained from the hardening resources inventory team.
- C. Time: Estimate the amount of time available to accomplish hardening tasks.

3. Develop a list of possible hardening methods:
 - A. Consider all possible variations (Booklet 9) of the following basic hardening alternatives:
 - (1) Evacuate to safe location (transport to distant low-risk area). First choice wherever practical.
 - (2) Move to new location and harden (improve location within building or move outdoors).
 - (3) Harden in place (for difficult to move equipment).
 - (4) Harden replacement equipment or alternative process equipment.
4. Evaluate each hardening method -- Test for "acceptability" and improved outcome. Primary criteria for acceptance are:
 - A. Resources are available (possible to accomplish) -- manpower, equipment, tools, materials and time are available to accomplish hardening method.
 - B. Method is expedient -- accomplished in short period of time.
 - C. Significantly improves survival blast rating.
 - D. Significantly reduces the recovery time.
5. Choose the hardening method that is the best blend of 4A through 4D and allows as many pieces of equipment to be treated as possible.
6. Fill in the appropriate data on the Hardening Decision Worksheet and assign teams, resources, and a schedule to complete.

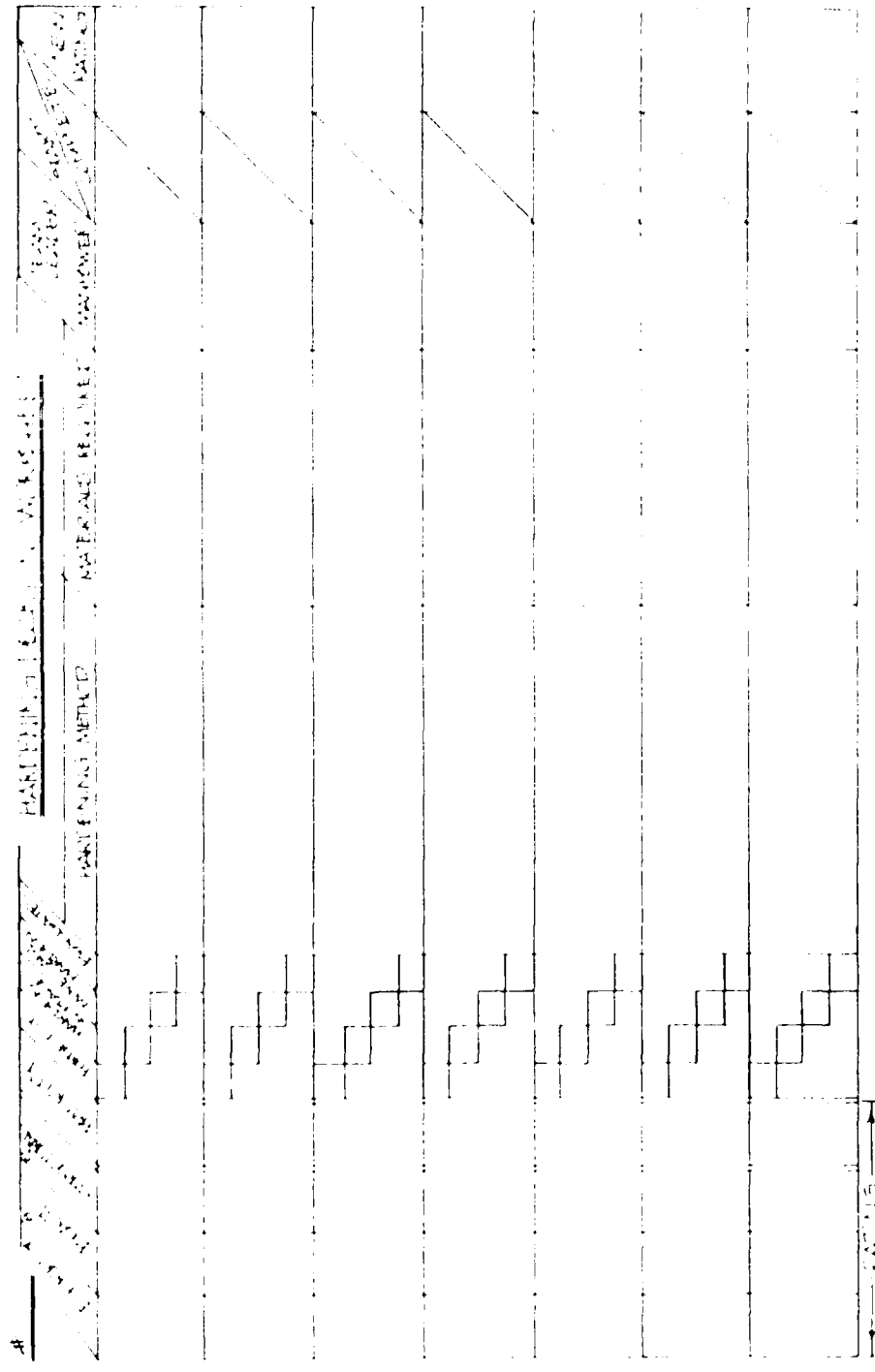
ALSO SEE BUILDING AREA
 SQUAD MEMBERS
 1. BOB
 2. JOHN
 3. JOHN

ITEM NO.	EQUIPMENT NAME AND DESCRIPTION	QTY	SIZE	REMARKS	SHIFT DOWN TIME	E	R	BLAST	STROKES	PRIORITY	HARDENING METHOD	MATERIALS REQUIRED	USE	T-1	T-2	T-3	T-4	T-5	T-6	T-7	T-8	T-9	T-10	T-11	T-12	T-13	T-14	T-15	T-16	T-17	T-18	T-19	T-20		
1	TRIN AND SHAP TABLE WITH DIES AND PATTERN (1/2" IN DIAMETER (1/2" IN DIAMETER))	1	3' 4' 6'	1-IN THICK TABLE TOP NOT AFFIXED VERY HEAVY	0	4	2	0	2	0	INVERT PLACE NEXT TO CONCRETE CURED	FOR LIFT HAND TOOLS	USE C +																						
2	WELDING AREA WITH PORTABLE WELD (5' (MIG))	3	3' 2' 5'	SMALL WELDERS AND TABLES	0	2	2	4	4	2	EVALUATE WELDERS INVERT TABLES DO LAST!	FOR LIFTS TRUCK RAMP	USE C 2																						
3	WATER TEST (DIP) TANK FOR TESTING RADIATORS	1	3' 3' 6'	NOT AFFIXED	0	2	4	0	2	2	LEAVE FULL AFFIX TO FLOOR	EQUIPMENT EVALUATE ELECTRIC DRILL HAND TOOLS	N/A																						
4	CANTINULES WELD WELDERS ON AGES BOTTOM RATE 10' SQUARE	4	6' 4' 6'	WITH FOUR 1/2-IN. BITE	0	4	3	7	3	2	UNBOLT AND EVALUATE	SMALL FOR LIFT TRUCK HAND TOOLS	USE C +																						
5	4,000-110 CAPACITY FOR LIFT	2	6' 4' 6'	SOLID-TIERED, LPS-DOWNED HANDLERS	0	2	3	5	0	2	PUT ON TRUCK LAST AND EVALUATE WITH PATTERNS AND DIES DO LAST!	RAMP TO TRUCK TRUCK	USE C 2																						
6	DIES AND PATTERNS										PUT ONE IN EACH PRESS AND CLOSE EVALUATE ALL OTHERS																								
7	MATERIAL STICKS										BAND TOGETHER LIE FLAT, SOME STACKS PLACED BETWEEN PLATENS OF PRESSES DO LAST!																								
EX-15																																			

DATE: _____

HARDENING DESIGN WORKSHEET									
TEAM	LEADER	TEAM MEMBER	TEAM MEMBER	TEAM MEMBER	TEAM MEMBER	TEAM MEMBER	TEAM MEMBER	TEAM MEMBER	TEAM MEMBER
HARDENING METHOD			MATERIALS REQUIRED				NEW RATINGS		
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
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1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
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1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6				

Case



$A+B+C$ (lower sum)

#

#	HARDENING TECHNIQUE				HARDENING METHOD	MATERIALS REFERENCE				TESTING METHOD			
	PLASTICITY	STRUCTURAL	PROPERTIES	STRENGTH		PLASTICITY	STRUCTURAL	PROPERTIES	STRENGTH				

PRIORITY = A + B OR A + C (lower sum)

先

#	HARDENING METHOD			MATERIALS REQUIRED			HARDENING METHOD			MATERIALS REQUIRED		
	TEMP.	TIME	METHOD	TEMP.	TIME	METHOD	TEMP.	TIME	METHOD	TEMP.	TIME	METHOD
1	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil
2	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil
3	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil
4	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil
5	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil
6	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil
7	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil
8	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil
9	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil
10	100	1	Oil	100	1	Oil	100	1	Oil	100	1	Oil

PRIORITY = A + B OR A + C (lower sum)

二

[illegible]
$$\text{Fugacity} = A + B \alpha \quad A + C \quad (10 \text{ over sim})$$

INDUSTRIAL

PROTECTION

GUIDE

✓

CRISIS RELOCATION
INDUSTRIAL HARDENING PLAN
***VULNERABILITY
BLAST RATING
CATALOG
&
EQUIPMENT
INDEX***
BOOKLET 8

SCIENTIFIC SERVICE, INC.

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 8A

VULNERABILITY/BLAST RATINGS CATALOG

This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

Booklet 8A

VULNERABILITY/BLAST RATING CATALOG

Hardening Operations Manager: _____
(name)

Alternate: _____
(name)

Objective: To find equipment blast ratings (to enter in column B of worksheets provided in Booklet 7).

To find a way to protect your equipment you must find its vulnerability to a blast wave.

Blast ratings are affected by:

1. Equipment weight
2. Equipment size
3. How equipment is made
 - (a) Framework, coverings
 - (b) Internal or external parts that are essential to its functioning
4. The ratio of height to the smaller dimension of the base it stands on.

TO DETERMINE THE BLAST RATING OF A PIECE OF EQUIPMENT:

1. Find it in the Equipment Index (Booklet 8B, attached) and obtain the category designation located to the right of the page.

The category designation is in three parts consisting of Group (Numbers 1-3), Section (Letters A-G), and Class (Numbers 1-4). This catalog is color-coded so that:

- Group 1 is pink. Items fit into a box 4 x 4 x 8 feet (so would fit a truck bed)
- Group 2 is green. Items fit into a box 15 x 15 x 20 feet (but not a group 1 box)
- Group 3 is yellow. Items too large to fit a group 2 box.

2. Look up category designation in this catalog (starting after page 10) and get the "Survival Blast Rating with Protective Housekeeping," according to whether it is "secured" or "unsecured." If protective housekeeping is physically impossible, use the Light-to-Moderate damage rating according to whether the item is "secured" or "unsecured". (If a violent earthquake could tip it over, it is "unsecured" even if it is fastened; e.g., tall pieces of equipment on small bases.)

3. For Blast Rating listings -- Each page is divided into **Low Profile** ($H/B \leq 2$) and **High Profile** ($H/B > 2$). From the dimensions logged on the equipment inventory sheet, decide which to use.

Definitions:

- ($H/B \leq 2$): The height is less than, or equal to, two times the smaller dimension of the base.
- ($H/B > 2$): The height is over two times the smaller dimension of the base.

4. Enter the appropriate Blast Rating number on the Booklet 7 decision worksheet under BLAST (column B).

If the machine is not listed where you look first, try to find it under another name. If you still cannot find it, look up the name of a couple of pieces of equipment built like the one you're looking for, and use an average for those categories, since things built alike react somewhat alike to blast effects.

If you can't find a rating category by any of these methods, use your best judgment and fit the item to the list of equipment categories that follow (pages 5 - 10):

- o Look in the proper **size group** (listed at the bottom of pages 5 -10)
- o Find the **section** in that group that is closest to your machine's type. Each of the three size groups is divided into sections (A, B, C, etc.) representing different types of equipment.
- o Pick the description under **class** that fits best. Each section has two or more classes (A-1, A-2, etc.) of equipment.

See example on the following page.

EXAMPLE: Roll Forming Machine — H = 5', W = 12', L = 6' (not in Index 8B)

5' x 12' x 6'

Size Group 2*

Medium & heavy duty machinery

Section A**

Heavy frame construction

Class 2

Equipment Category -- 2A-2

H/B = 5/6 (H over the smaller of W and L)

Look up this category number (also the page number in the bottom left-hand corner) in the corresponding color-coded Vulnerability Ratings section, following page 10 (coded green for this example) and get the Blast Rating.

Enter this Blast Rating in column B on the decision worksheet from Booklet 7.

Page 2A-2 shows ratings for $H/B \leq 2$. If protective housekeeping is completed, the rating is 6, provided the machine is outdoors away from structures and secured. It is 4 if the machine is outdoors, away from structures and unsecured. Without housekeeping, loose items become missiles, so that, even secured, the rating would be 3 (light to moderate damage) or 6 (moderate to heavy damage). Indoors, the building will collapse on it at 2 psi, the structure rating, so the rating would be 2.

* Color-coded green. Start on page 7 and look for section that best fits.

** With section established, select class that best fits.

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INDUSTRIAL PROTECTION MANUAL.(U)

F/G 15/3

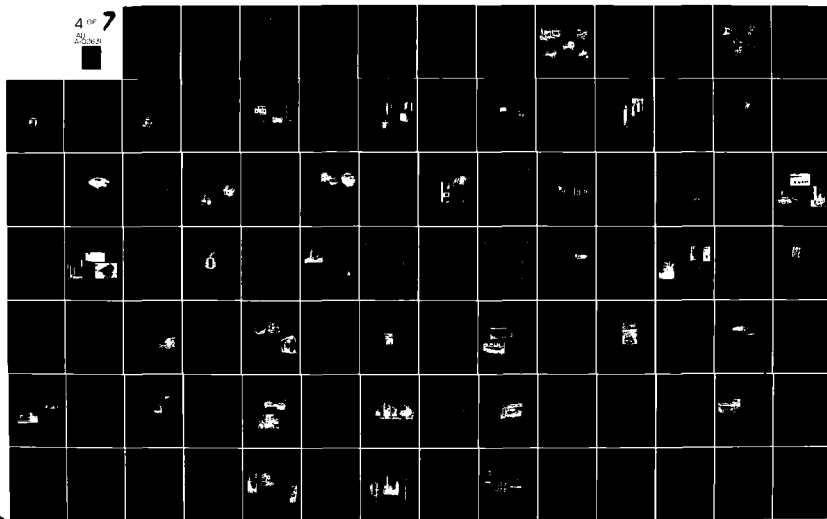
JUN 81
SSI-8011

EMW-C-0154

NL

UNCLASSIFIED

4 of 7
DUPLICATE
■



SECTION A: SMALL MACHINERY/MECHANICAL EQUIPMENT

CLASS	EXAMPLE
1. Portable lightframe equipment	Portable heaters, steam boilers, blowers, air conditioners
2. Skid or frame-mounted mechanical equipment	Compressors, hoists, vacuum pumps, liquid pumps
3. Machine tools/metal & wood working equipment	Light drill presses, band saws, lathes presses

SECTION B: ELECTRICAL/ELECTRONIC EQUIPMENT AND INSTRUMENTATION

CLASS	EXAMPLE
1. Rugged portable electrical equipment	All metal power hand tools
2. Delicate portable electrical and panel/rack/machine mounted equipment	Plastic encased power hand tools, flowmeters, temperature recorders, meters, gauges, amplifiers, oscilloscopes
3. Electrical power distribution equipment	Insulators, standoffs, capacitors, circuit breakers (free-standing)
4. Motors	A.C. and D.C. motors

INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 1: $\leq 4' \times 4' \times 8'$, $\leq 1,000$ lb.

SECTION C: THIN-WALLED CONSTRUCTION, BINS, DRUMS, etc. (Use for Hardening Resource, Booklet 5)

CLASS	EXAMPLE
1. Containers	File cabinets, "tote" boxes, hoppers, desks, 55-gallon drums, bins, trays
2. Hoods, cabinets, enclosures	Paint spray booths, fume hoods, machine covers and guards, fan housings

SECTION D: PRESSURE VESSELS/HEAVY-WALLED VESSELS

CLASS	EXAMPLE
1. Portable pressurized bottles and cylinders	High pressure gas cylinders, liquefied gas bottles
2. Fixed heavy-walled vessels	Cook kettles, autoclaves, centrifuges

INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 1: $\leq 4' \times 4' \times 8'$, $\leq 1,000$ lb.

SECTION A: MEDIUM & HEAVY DUTY MACHINERY/MECHANICAL EQUIPMENT

- | CLASS | EXAMPLE |
|-----------------------------|--|
| 1. Light frame construction | Separators, sifters and classifiers, screw mixers, light commercial printing presses |
| 2. Heavy frame construction | Injection molding presses, extruders, forges, milling machines, casting machines |

SECTION B: ELECTRICAL/ELECTRONIC UNITS & PROCESS CONTROL

- | CLASS | EXAMPLE |
|---|---|
| 1. Electrical generating equipment*
(*Resource: move portable units out) | Emergency or standby units, cogeneration systems, battery arrays |
| 2. Electrical/electronic panels and racks | Moderately sized power panels, process control panels, electric equipment racks, instrumentation panels |
| 3. Electrical power equipment | MVA transformers, free standing circuit breakers, large switchgear |
| 4. Motors | |

SECTION C: THIN-WALLED CONSTRUCTION (Use for Hardening Resource, Booklet 5)

- | CLASS | EXAMPLE |
|---------------------------------|--|
| 1. Movable items | Dumpsters, "tote" boxes, shipping containers |
| 2. Stationary floor/pad mounted | Sandblast cabinets, paint spray booths, noise enclosures, material bins, light storage tanks |
| 3. Elevated constructions | Hoppers, elevated tanks, baghouses |

INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 2: $\leq 15' \times 15' \times 20'$, $\leq 30,000$ lb.

SECTION D: HEAVY-WALLED OR PRESSURE VESSELS

CLASS	EXAMPLE
1. Movable	Transfer tanks, LPG trucks
2. Stationary liquid or gas storage	LPG storage, high pressure gas storage
3. Material processing	Autoclaves, reactors

SECTION E: MECHANICAL HANDLING EQUIPMENT

CLASS	EXAMPLE
1. Mobile*	Forklifts, loaders
2. Movable-tracked/limited	Bridge cranes, monorail crane, balance arms
3. Stationary	Conveyors, can/bottle handlers and fillers, material elevators

SECTION F: REFRACTORY OR MASONRY WALLED EQUIPMENT

CLASS	EXAMPLE
1. Simple constructions	Box type furnaces, ovens
2. Other lined equipment	Boilers, arc and induction furnaces, stacks to 30 feet, small calciners, ladles

* Potential resource.

INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 2: $\leq 15' \times 15' \times 20'$, $\leq 30,000$ lb.

SECTION A: LARGE MECHANICAL EQUIPMENT

CLASS

EXAMPLE

- | | |
|--|--|
| 1. Assemblies and light-framed constructions | Printing presses, looms |
| 2. Heavy frame equipment | Large presses, large forges, slab/billet mills |

SECTION B: UTILITY DISTRIBUTION EQUIPMENT

CLASS

EXAMPLE

- | | |
|---|--|
| 1. Power generating equipment | Generators — MVA class |
| 2. Panels and racks (heavy frame, enclosed) | Main distribution panels |
| 3. Distribution equipment | Powerlines, air lines, conduits, buses |
| 4. Substation-type equipment | MVA class breakers, main transformers |

SECTION C: LIGHT-WALLED CONSTRUCTION (Use for Hardening Resource, Booklet 5)

CLASS

EXAMPLE

- | | |
|---------------------------|---|
| 1. Mobile, temporary | Temporary vision screens (walls), large doors and covers |
| 2. Enclosures and rooms | Sandblast cabinets, paint spray booths, Equipment sheds, noise enclosures |
| 3. Material storage units | Large bins, tanks |
| 4. Elevated constructions | Baghouses, large hoppers, cooling "towers" |

INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 3: > 15' x 15' x 20', > 30,000 lb.

SECTION D: HEAVY-WALLED AND PRESSURE VESSELS

- | CLASS | |
|-------------------------------------|--|
| 1. Mobile* (*potential resource) | |
| 2. Stationary liquid or gas storage | |
| 3. Material processing | |

EXAMPLE
LPG trucks, high pressure gas trucks
LPG storage, LNG storage
Autoclaves, reactors, "cat" crackers

SECTION E: MECHANICAL MATERIAL HANDLING EQUIPMENT

- | CLASS | |
|----------------------------------|--|
| 1. Mobile* (*potential resource) | |
| 2. Movable-tracked/limited | |
| 3. Stationary | |

EXAMPLE
Locomotives, large trucks/carriers
Large bridge cranes, monorail cranes, rail car dumpers, portable conveyors
Can feeders, conveyors, material elevators

SECTION F: REFRACTORY/MASONRY-WALLED EQUIPMENT

- | CLASS | |
|----------------------------|--|
| 1. Simple constructions | |
| 2. Special lined equipment | |
| 3. Stacks | |

EXAMPLE
Box-type furnaces & ovens, masonry buildings & vaults, concrete block structures
Boilers, arc & induction furnaces, calciners
Refractory/brick chimneys and stacks

SECTION G: METAL TOWERS AND COLUMNS

- | CLASS | |
|------------------------|--|
| 1. Assemblies | |
| 2. Rigid constructions | |

EXAMPLE
Transmission towers, scaffolding, catwalks
Distillation towers, cat crackers, metal stacks

INDUSTRIAL EQUIPMENT CATEGORIES — GROUP 3: > 15' x 15' x 20', > 30,000 lb.

VULNERABILITY RATINGS

GROUP 1

TYPE: PORTABLE LIGHT FRAME EQUIPMENT

EQUIPMENT PAGE NO. 1A-1

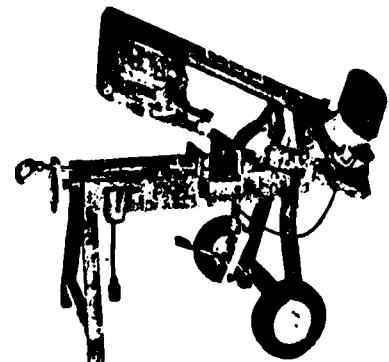
Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EXAMPLES

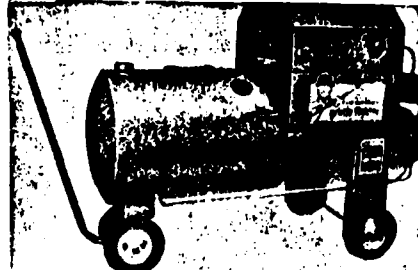
Portable Blowers
Portable Heaters
Window Type Air Conditioners
Portable Pumps
Steam "Jennies"



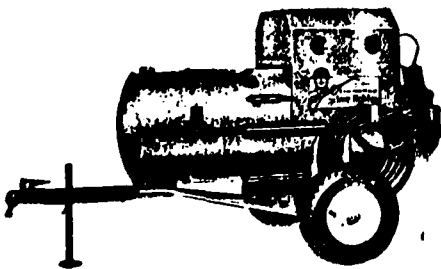
Portable Mixer



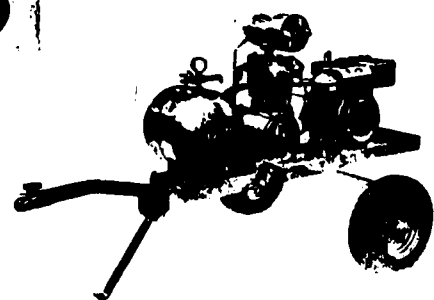
Mobile Band Saw



Steam Cleaner



Portable Steam Cleaner



Portable Compressor

VULNERABILITY RATINGS

GROUP 1

GROUP: 1A-1 PORTABLE LIGHT FRAME EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u>					-	-
2. <u>Light to moderate damage:</u> Small tanks broken off, gauge metal covers damaged, minor frame damage		-	1.0	1.0	8	1
3. <u>Moderate to heavy damage:</u> Frame requires major repair or replacement; electric motors broken; new covers, pullies, fan belts, etc. required		4	3	2	40	7
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	2		2	0.5
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>						
3. <u>Moderate to heavy damage:</u>						
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING						
PAGE 1A-1		PORTABLE LIGHT FRAME EQUIPMENT				

SKID OR FRAME MOUNTED MECHANICAL EQUIPMENT

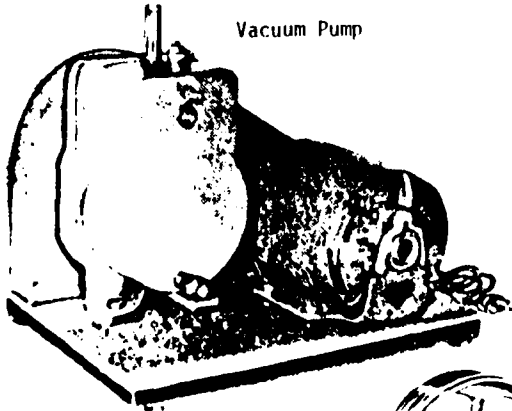
EQUIPMENT PAGE NO.

1A-2

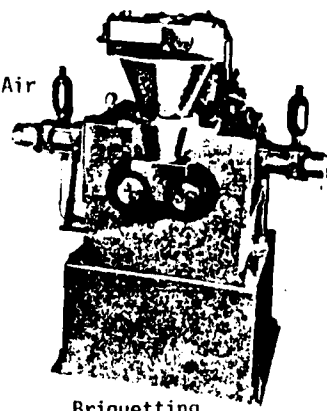
TYPE: Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EXAMPLES

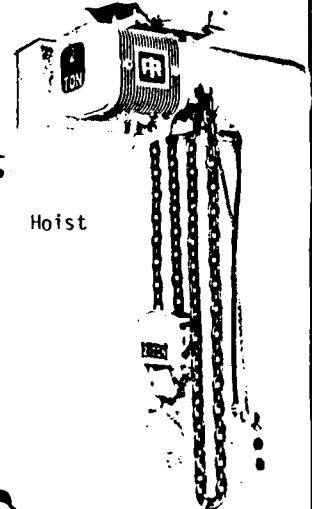
Liquid Pump Units
Refrigeration, Fixed Air
Conditioning Units
Compressors
Hoists
Vacuum Pumps
Hydraulic Pumps



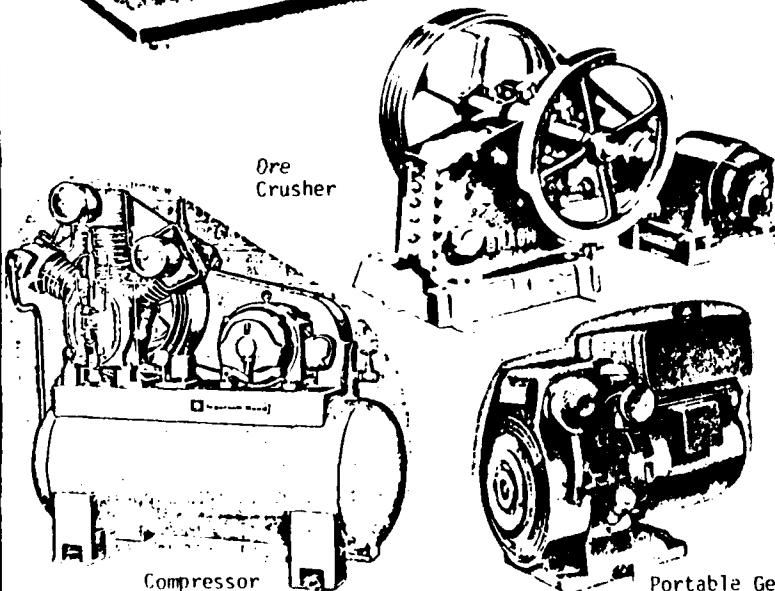
Vacuum Pump



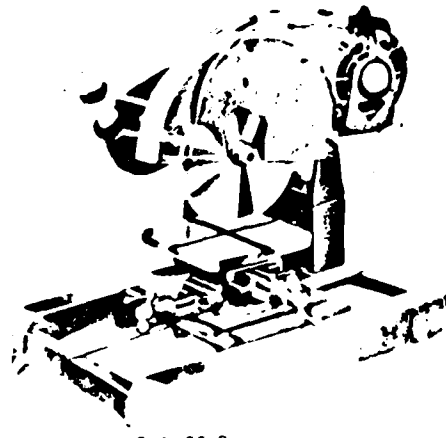
Briquetting
Machine



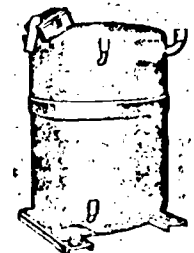
Hoist



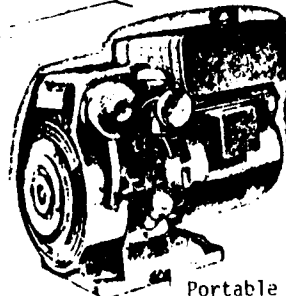
Ore
Crusher



Cutoff Saw



Sealed
Compressors



Portable Generator

Compressor

GROUP: 1A-2 SKID OR FRAME MOUNTED MECHANICAL EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
1. <u>Little or no damage:</u>				-	-
2. <u>Light to moderate damage:</u> Damaged piping, gauges, control boxes, handles, fan belts, small valves, etc.	2	2	1.5	8	1
3. <u>Moderate to heavy damage:</u> Motors broken; minor frame damage; new controls required	10	6	4	40	15
4. <u>Destroyed:</u> Replacement equipment required					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	4		4	1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>				-	-
2. <u>Light to moderate damage:</u> (see above)	2	1.5	1.5	8	1
3. <u>Moderate to heavy damage:</u> (see above)	8	4	3	40	15
4. <u>Destroyed:</u> Replacement equipment required					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	5	3		4	1
PAGE 1A-2	SKID OR FRAME MOUNTED MECHANICAL EQUIPMENT				

TYPE: MACHINE TOOLS/METAL AND WOOD WORKING EQUIPMENT

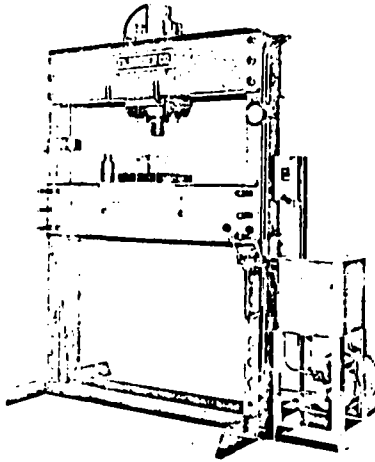
EQUIPMENT PAGE NO.

1A-3

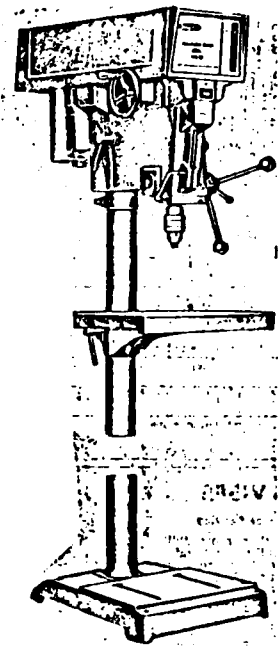
Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EXAMPLES

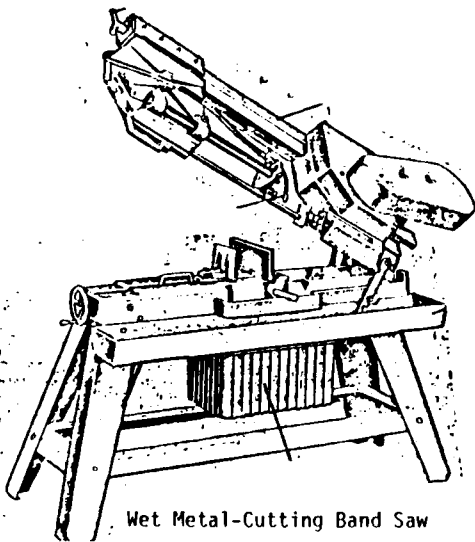
Light Drill Presses
Band Saws
Lathes
Presses



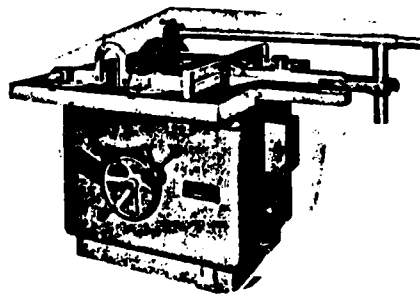
Hydraulic Press



Drill Press



Wet Metal-Cutting Band Saw



Tilting Arbor Saw

GROUP: 1A-3 MACHINE TOOLS/METAL & WOOD WORKING EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u> Damaged wiring, covers, work lights, guards; some controls inoperative		2	2	1.5	8	1
3. <u>Moderate to heavy damage:</u> Hand wheels and controls broken; motor damaged; some frame damage		6	4	3	40	10
4. <u>Destroyed:</u> Replacement required						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	3		4	1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u> (see above)		2	1.5	1.5	8	1
3. <u>Moderate to heavy damage:</u> (see above)		4	3	3	40	10
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	3		4	1
PAGE 1A-3		MACHINE TOOLS METAL & WOOD WORKING EQUIPMENT				

TYPE: PORTABLE ELECTRICAL EQUIPMENT, RUGGED

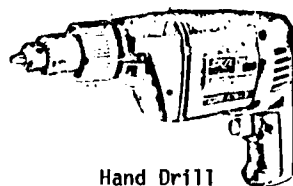
Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EQUIPMENT PAGE NO. 1B-1

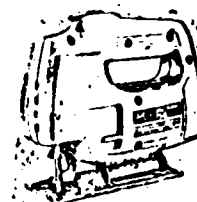
EXAMPLES

Power Hand Tools

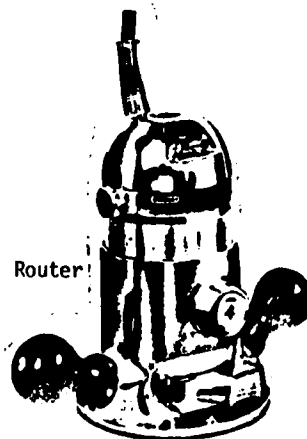
Welding Machines



Hand Drill



Jig Saw



Router

GROUP: 1B-1 PORTABLE ELECTRICAL EQUIPMENT, RUGGED	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)					
1. <u>Little or no damage:</u>		-	-		
2. <u>Light to moderate damage:</u> Covers jam against components; plastic components break or shatter	5.0	3.0	3.0	4	1
3. <u>Moderate to heavy damage:</u> Covers short out electrical components; knobs, switches broken from missiles and impact	10.0	5.0	5.0	8	1
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	8	4		2	< 1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>					
3. <u>Moderate to heavy damage:</u>					
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 1B-1	PORTABLE ELECTRICAL EQUIPMENT				

TYPE:

PANEL/RACK/MACHINE MOUNTED EQUIPMENT

EQUIPMENT PAGE NO.

1B-2

Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EXAMPLES

Flowmeters

Temperature Recorders

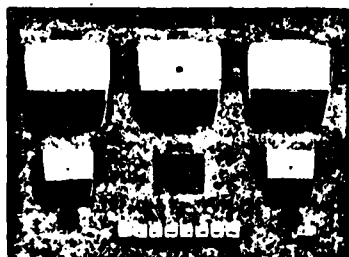
Meters

Gauges

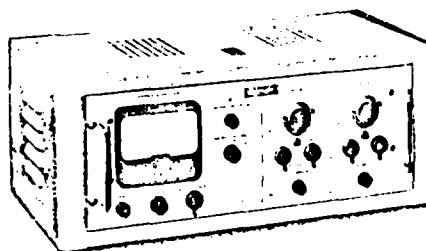
Amplifiers

Recorder/controller

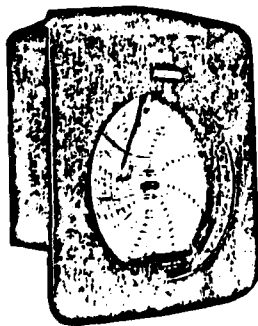
Arc Welders



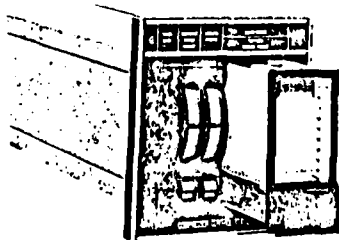
O-Type Current Meter System (Panel)



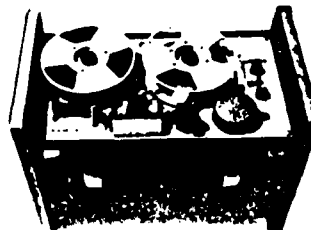
Two Channel Carrier
Amplifier System



Foxboro Pneumatic
Recorder (Field Mounted)



Fisher Electronic
Recorder (Panel Mounted)



Recorders



Allen-Bradley
N/C Unit

GROUP: 1B-2 PANEL/RACK/MACHINE MOUNTED EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Some meters damaged					
2. <u>Light to moderate damage:</u> Meters broken; Panels/covers bent; vacuum tubes broken	1	1	1	4	1
3. <u>Moderate to heavy damage:</u> Mechanical linkages damaged; controls broken; cathode ray tubes broken; front panels bent; covers jammed against internal components; panel/rack may overturn	3	2	2	8	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2	2		2	< 1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	1	1	1	4	1
3. <u>Moderate to heavy damage:</u>	2	2	2	8	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2	2		2	< 1
PAGE 1B-2	PANEL/RACK/MACHINE MOUNTED EQUIPMENT				

TYPE: ELECTRICAL POWER DISTRIBUTION EQUIPMENT

EQUIPMENT PAGE NO. 1B-3

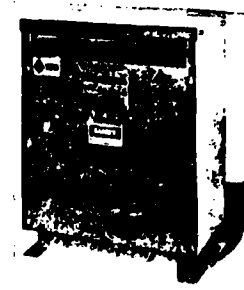
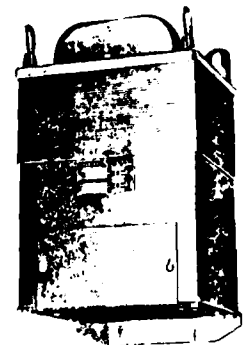
Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EXAMPLES

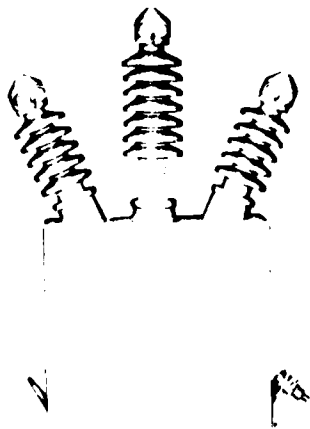
Starter/Disconnect
Transformer
Capacitors



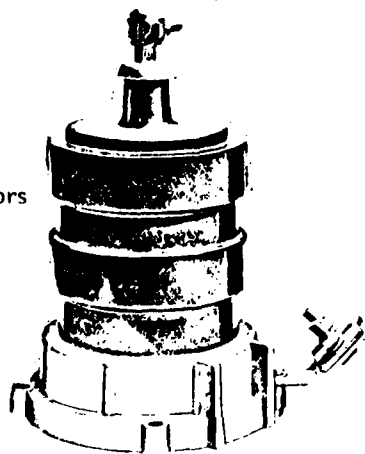
Starter/Disconnect



Transformer



Capacitors



GROUP: 1B-3 ELECTRICAL POWER DISTRIBUTION EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Panels/covers bent					
2. <u>Light to moderate damage:</u> Radiators on transformers bent and leaking; covers/panels blown against internal components; broken standoffs & mounts; plastic components broken.	2	2	1	24	4
3. <u>Moderate to heavy damage:</u> Cases/cans short out capacitors; insulators broken; wires torn from connections; oil-filled units leaking; piping damaged; controls broken	4	3	3	48	8
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	3		3	< 1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2	2	2	24	4
3. <u>Moderate to heavy damage:</u>	4	3	3	48	8
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	3		4	< 1
PAGE 1B-3	ELECTRICAL POWER DISTRIBUTION EQUIPMENT				

TYPE: MOTORS

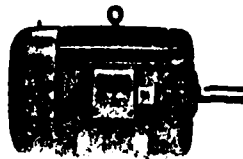
EQUIPMENT PAGE NO. 18-4

Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

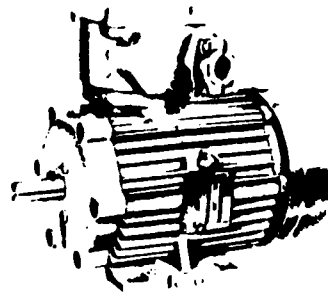
EXAMPLES

High Efficiency Motor

Hazardous Duty Motor



High Efficiency Motor



Hazardous Duty Motor

GROUP: 1B-4 MOTORS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	INDUCTION (AC)	DC or SYNCHRONOUS			
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2) 1. <u>Little or no damage:</u> Power connection covers bent; access panels deformed 2. <u>Light to moderate damage:</u> Covers blown into splices and/or commutator (or slip ring) assemblies; some wiring pulled loose at terminations. 3. <u>Moderate to heavy damage:</u> Motors mounts broken; windings damaged by missiles and deflecting covers; shaft misalignment. 4. <u>Destroyed:</u>					
	4	3	2	4	<1
	8	6	4	6	<1
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	5		2	< 1
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	6		2	< 1

PAGE 1B-4

MOTORS

PORTABLE PRESSURIZED BOTTLES AND CYLINDERS

TYPE:

Maximum Dimensions: (4x4x8) Feet

Maximum Weight: 1,000 Pounds

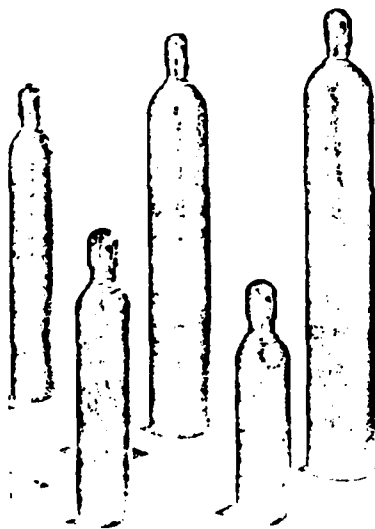
EQUIPMENT PAGE NO.

1D-1

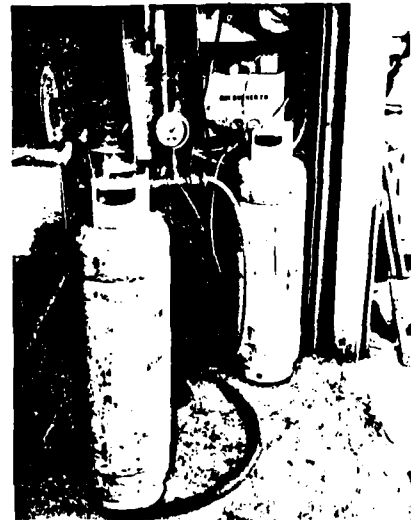
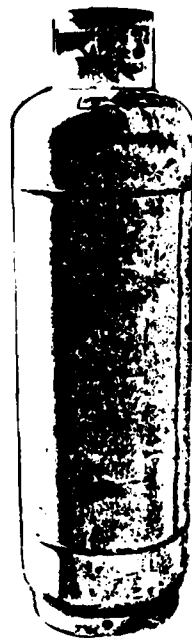
EXAMPLES

High Pressure Gas Bottles

Liquefied Gas Bottles



High Pressure Gas Cylinders



Gas Cylinders

GROUP: 1D-1 PORTABLE PRESSURE/HEAVY-WALLED VESSELS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS	
	SECURED	NOT SECURED				
1. <u>Little or no damage:</u> Regulators and light accessories damaged						
2. <u>Light to moderate damage:</u> Missiles dent sides & break light accessories; overturning	100	10	4	4	1	
3. <u>Moderate to heavy damage:</u> Piping ruptured; major damage to accessories; leaks produced	200	20	8	8	1	
4. <u>Destroyed:</u> Container unusable for pressures						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		150	15		1	< 1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>	100	10	4	4	1	
3. <u>Moderate to heavy damage:</u>	200	20	8	8	1	
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		150	15		1	< 1
PAGE 1D-1		PORTABLE PRESSURE/HEAVY-WALLED VESSELS				

TYPE: FIXED HEAVY-WALLED VESSELS

EQUIPMENT PAGE NO. 1D-2

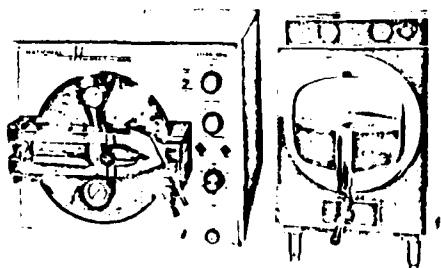
Maximum Dimensions: (4x4x8) Feet — Maximum Weight: 1,000 Pounds

EXAMPLES

Cook Kettles

Autoclaves

Mixers



Autoclave/Dryer



Mixer/Muller



Steam Jacketed Kettle

GROUP: 1D-2 FIXED HEAVY-WALLED VESSELS		BLAST LEVEL (PSI)		RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED				
1. <u>Little or no damage:</u> Light accessory damage					
2. <u>Light to moderate damage:</u> Accessories damaged; covers deformed	2		2	8	1
3. <u>Moderate to heavy damage:</u> Loose components blown off; denting of walls evident; displaced off mountings; pressure seals & surfaces heavily damaged; controls destroyed	4		4	12	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3			2	1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2		2	8	1
3. <u>Moderate to heavy damage:</u>	4		3	12	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3		3	2	1
PAGE 1D-2		FIXED HEAVY-WALLED VESSELS			

VULNERABILITY RATINGS

GROUP 2

TYPE: LIGHT FRAME MACHINERY/MECHANICAL EQUIPMENT

EQUIPMENT PAGE NO. 2A-1

Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

Separators

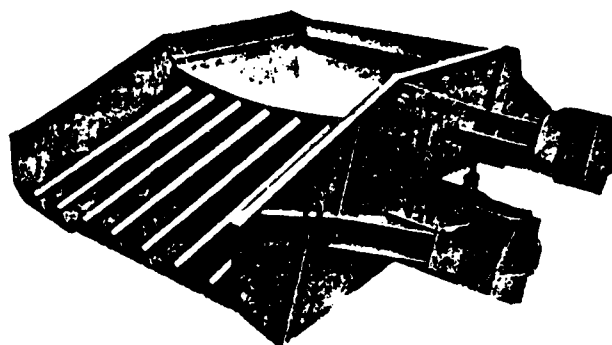
Sifters

Classifiers

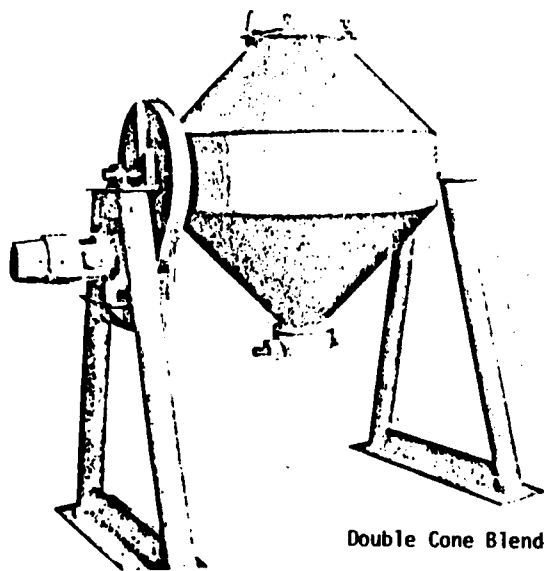
Screw Mixers

Light Commercial Printing Press

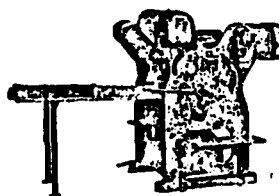
Feeders



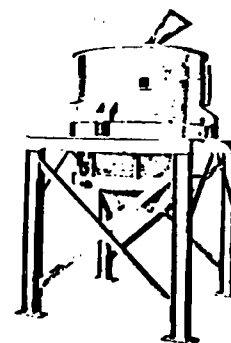
Grizzly Feeder



Double Cone Blender



Two-Color Printing Press



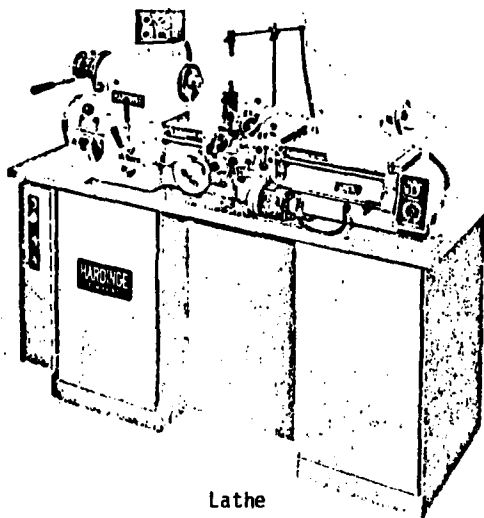
Coolant Separator

GROUP: 2A-1 LIGHT FRAME MACHINERY/MECHANICAL EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Some accessories damaged; Panels & covers bent					
2. <u>Light to moderate damage:</u> Panels & covers buckled and torn off; breakables fractured; internal components misaligned; controls damaged	2	1.5	1.5	16	3
3. <u>Moderate to heavy damage:</u> Unit displaced on frame; internal components damaged; frames & supports damaged; covers driven into internal components; controls destroyed	3	2	2	32	8
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	2		3	< 1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2	1	1	16	3
3. <u>Moderate to heavy damage:</u>	3	1.5	1.5	32	8
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	1		3	< 1
PAGE 2A-1	LIGHT FRAME MACHINERY/MECHANICAL EQUIPMENT				

TYPE: HEAVY FRAME MACHINERY/MECHANICAL EQUIPMENT

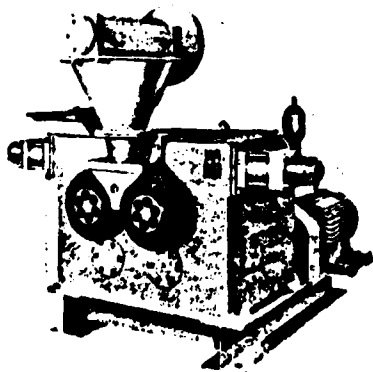
EQUIPMENT PAGE NO. 2A-2

Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds



Lathe

Briquetting Machine



EXAMPLES

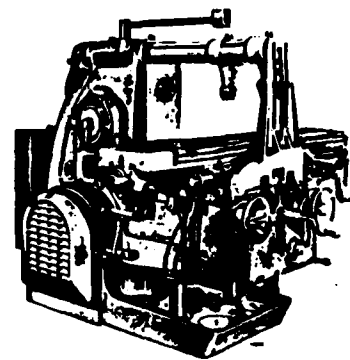
Injection Molding Presses

Extruders

Forges

Milling Machines

Casting Machines



Horizontal Milling Machine

GROUP: 2A-2 HEAVY FRAME MACHINERY/MECHANICAL EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Covers and guards bent						
2. <u>Light to moderate damage:</u> Covers damaged & torn off; wiring & light piping torn loose; exposed breakables fractured; electrical controls damaged; instrumentation broken; loose items blown off.		4	3	3	12	2
3. <u>Moderate to heavy damage:</u> Instruments destroyed; motors heavily damaged & misaligned; heavy piping torn loose; wiring torn loose; controls badly damaged; misalignment of major components; some frame damage		8	4	6	24	4
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		6	4		4	< 1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		3	3	2	16	2 - 3
3. <u>Moderate to heavy damage:</u>		6	4	5	32	5
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	4		4	< 1
PAGE 2A-2		HEAVY FRAME MACHINERY/MECHANICAL EQUIPMENT				

TYPE: ELECTRICAL GENERATING EQUIPMENT

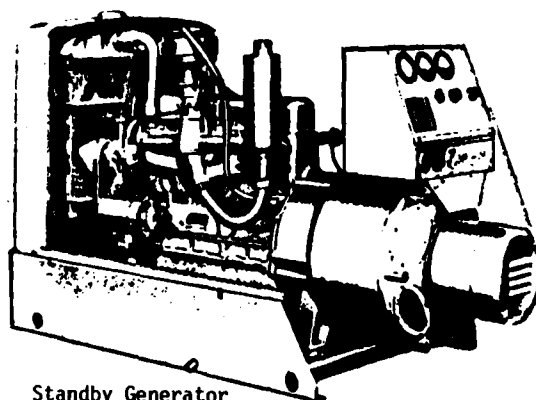
EQUIPMENT PAGE NO. 2B-1

Maximum Dimensions: (15x15x20) Feet

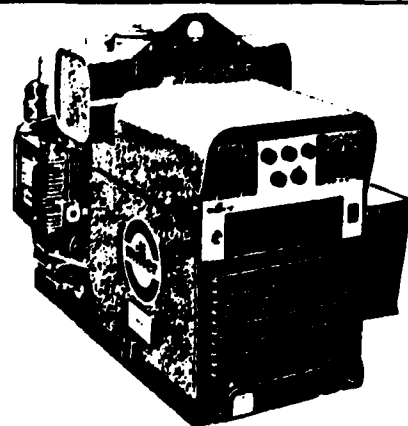
Maximum Weight: 30,000 Pounds

EXAMPLES

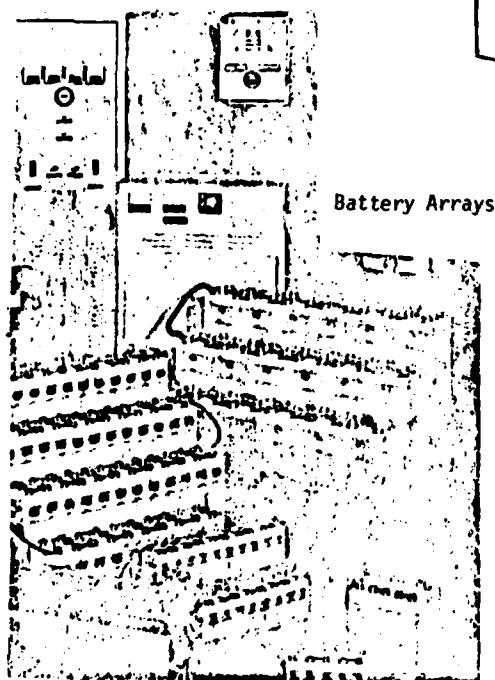
Emergency or Standby Units
Cogeneration Systems
Battery Arrays



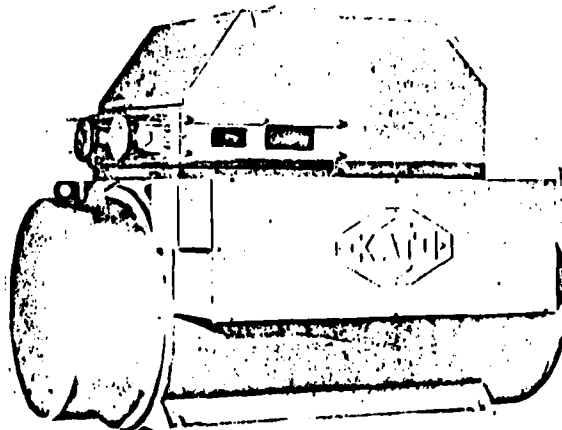
Standby Generator



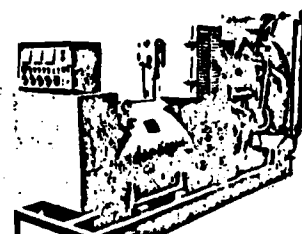
Standby Power Unit



Battery Arrays



Heavy Duty AC Generator



Diesel Electric Generator

GROUP: 2B-1 ELECTRICAL GENERATING EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)					
1. <u>Little or no damage:</u> Thin or light covers bent					
2. <u>Light to moderate damage:</u> Radiators on emergency power units damaged & leaking; instrumentation damaged; plate rectifiers damaged; some light control damaged	1.5		1	8	1
3. <u>Moderate to heavy damage:</u> Solid state components damaged by missiles; engines & generators displaced; motors damaged; controls broken; accessories heavily damaged	3		2	16	3
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2			3	< 1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>					
3. <u>Moderate to heavy damage:</u>					
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 2B-1	ELECTRICAL GENERATING EQUIPMENT				

TYPE:

ELECTRICAL/ELECTRONIC PANELS & RACKS

EQUIPMENT PAGE NO.

2B-2

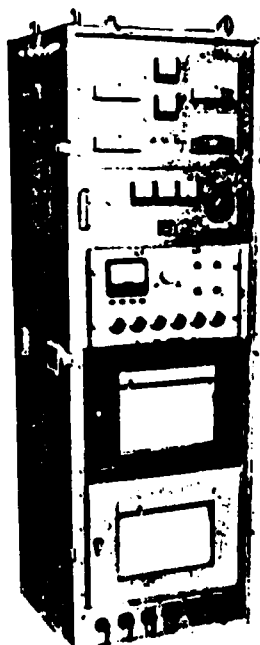
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

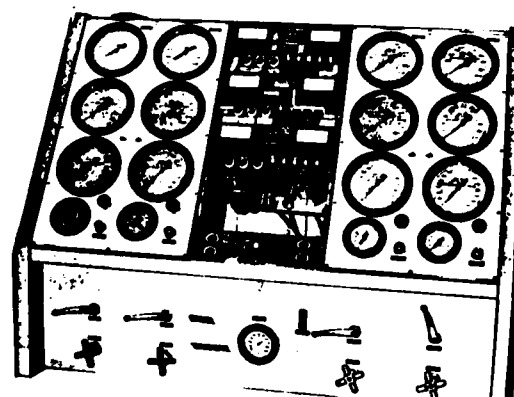
Control Panels

Instrumentation Panels

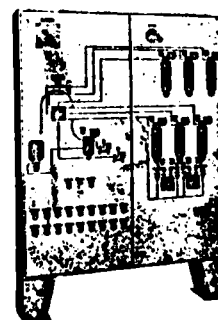
Instrumentation Racks



Instrumentation Rack



Instrumentation Panel



Control Panel

GROUP: 2B-2 ELECTRICAL/ELECTRONIC PANELS & RACKS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u> Meter movements broken; cover glasses broken; metal covers/panels bent; instruments decalibrated.		2	1	1	16	2
3. <u>Moderate to heavy damage:</u> Faces of panels bent/buckled with corresponding damage to elec. components; controls broken; covers & cases pushed into elec. components; breakables fractured; circuit boards cracked/broken.		4	2	2	24	4
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	2		3	< 1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		1	1	1		
3. <u>Moderate to heavy damage:</u>		3	2	2		
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		2	2			
PAGE 2B-2		ELECTRICAL/ELECTRONIC PANELS & RACKS				

ELECTRICAL POWER EQUIPMENT

EQUIPMENT PAGE NO.

2B-3

TYPE:

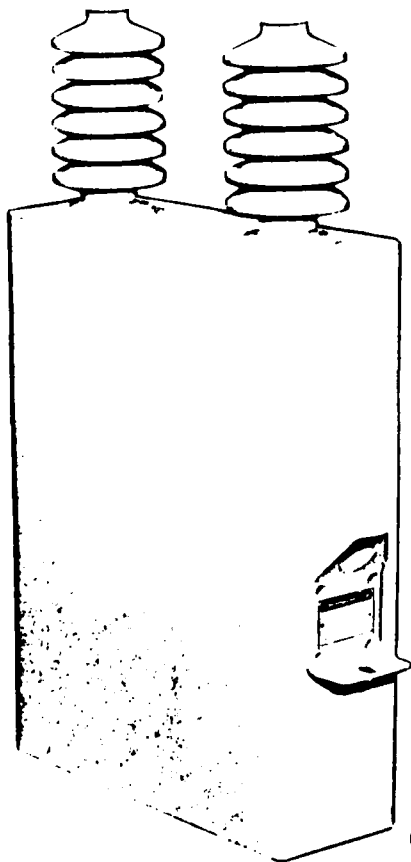
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

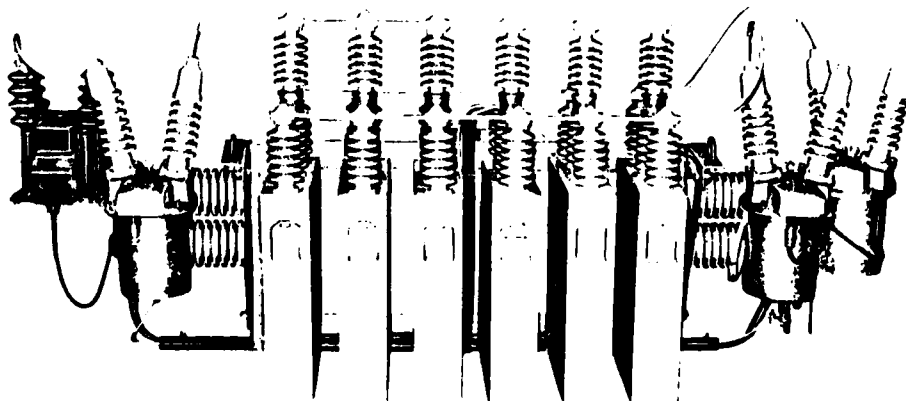
Capacitors

Transformer

Switchgear



Capacitor Unit

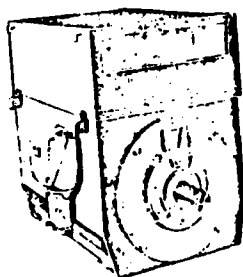


Capacitor Array

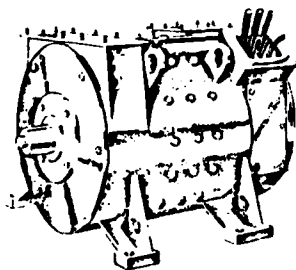
GROUP: 2B-3 ELECTRICAL POWER EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Distortion of radiators, cover plates.					
2. <u>Light to moderate damage:</u> Cooling radiators deformed & leaking; some insulators broken; wiring damaged.	3	2	2	8	1
3. <u>Moderate to heavy damage:</u> Insulators broken; cases damaged; switch gear heavily damaged by missiles & displaced covers and components; units displaced from foundations.	6	3	4	16	3
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	5	3		3	< 1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	3	2	2	10	2
3. <u>Moderate to heavy damage:</u>	4	4	3	24	3
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3		3	< 1
PAGE 2B-3	ELECTRICAL POWER EQUIPMENT				

TYPE: MOTORS
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

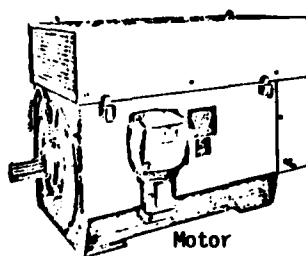
EQUIPMENT PAGE NO. 2B-4



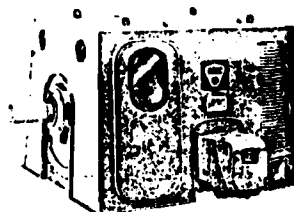
Motor



Motor



Motor



Motor

GROUP: 2B-4 MOTORS

DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	UNSECURED			
1. <u>Little or no damage:</u> Power connection covers bent; access panels deformed					
2. <u>Light to moderate damage:</u> Covers blown into splices and/or commutator (or slip ring) assemblies; some wiring pulled loose at terminations.	4	3	2	16	4
3. <u>Moderate to heavy damage:</u> Motors mounts broken; windings damaged by missiles and deflecting covers; shaft misalignment.	8	6	4	40	6
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	5		2	< 1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	3	2	2	20	4
3. <u>Moderate to heavy damage:</u>	8	4	4	48	8
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	3		2	< 1
PAGE 2B-4				MOTORS	

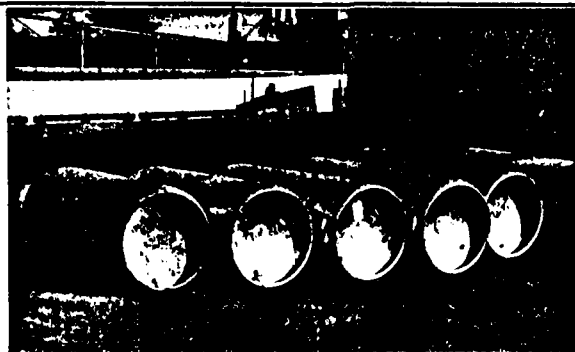
MOVABLE HEAVY-WALLED/PRESSURE VESSELS

EQUIPMENT PAGE NO. 2D-1

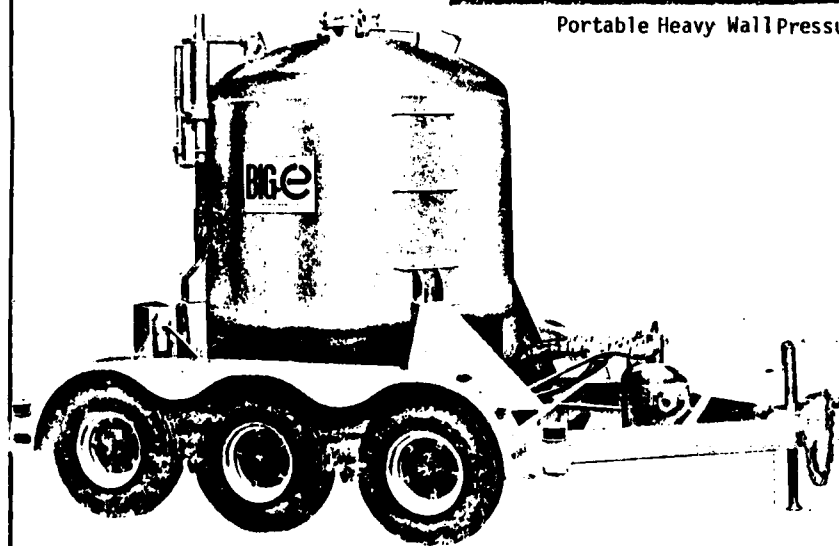
TYPE: Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

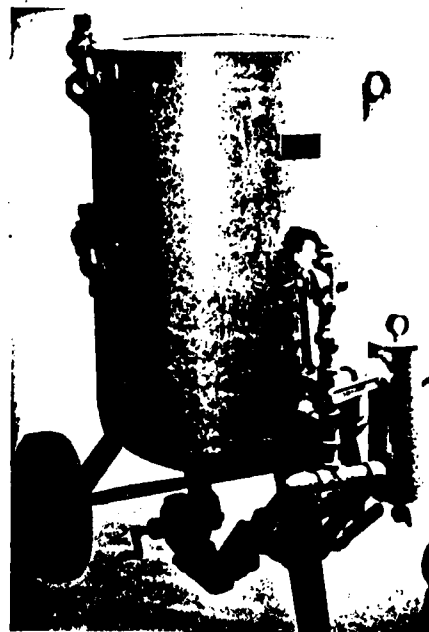
Transfer Tanks
LPG Trucks
Production Blasters
Pressure Vessels



Portable Heavy Wall Pressure Vessel



Production Blaster



Mobile Sand Blaster

GROUP: 2D-1 MOVABLE HEAVY-WALLED/PRESSURE VESSELS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Light accessory damage						
2. <u>Light to moderate damage:</u> Moderate accessory damage; some controls bent; light piping leaks at connections; tires punctured by missiles		2	1	1	8	1
3. <u>Moderate to heavy damage:</u> Heavy damage to pipe connections and controls; extensive leaking of vessel		4	2	2	16	2
4. <u>Destroyed:</u> Heavy damage to peripherals & accessories result in loss of structural integrity. Tank unsafe						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	2		2	< 1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>						
3. <u>Moderate to heavy damage:</u>						
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING						
PAGE 2D-1		MOVABLE HEAVY-WALLED/PRESSURE VESSELS				

TYPE: STATIONARY HEAVY-WALLED/PRESSURE VESSELS

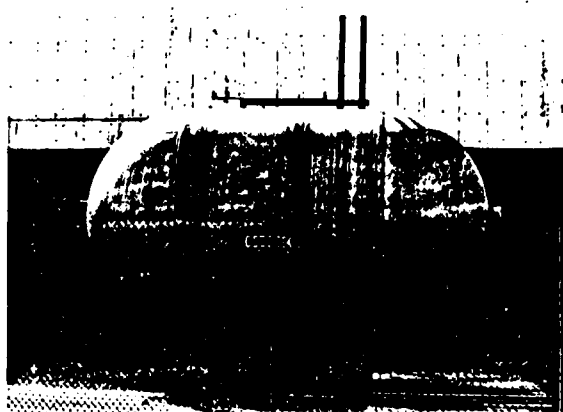
EQUIPMENT PAGE NO. 2D-2

Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

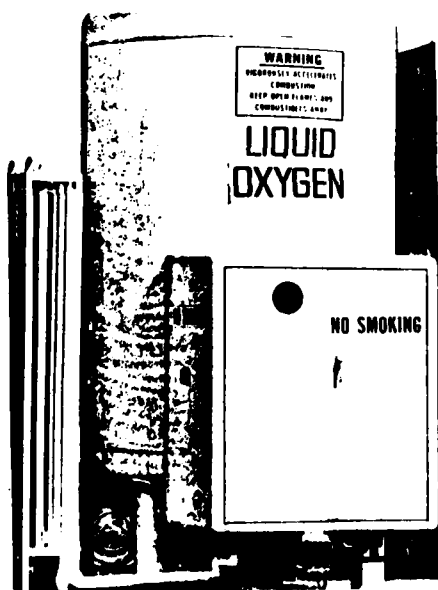
EXAMPLES

LPG Tank

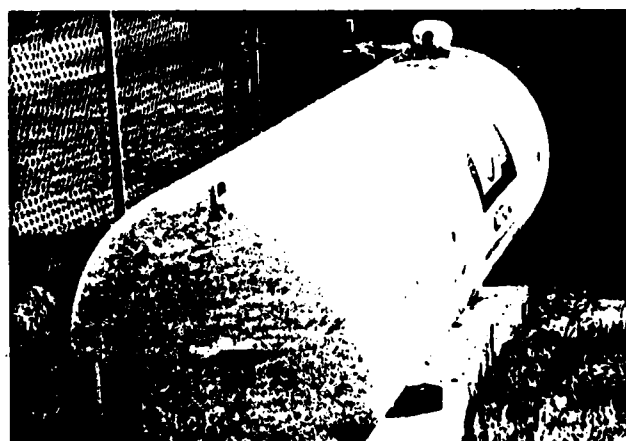
Gas Pressure Vessel



LPG Tanks



Gas Pressure Vessel



GROUP: 2D-2 STATIGJARY HEAVY-WALLED/PRESSURE VESSELS	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	FULL	EMPTY			
1. <u>Little or no damage:</u> Light accessories damaged					
2. <u>Light to moderate damage:</u> Light piping bent and leaking at connections; panels & covers bent/buckled or blown off; controls damaged; field-mounted instrumentation smashed.	4	3	2	20	3
3. <u>Moderate to heavy damage:</u> Very heavy accessory damage; major piping deformation with leaks; structural damage to supports; anchors fail; unit displaced on foundations.	8	6	4	120	20
4. <u>Destroyed:</u> Pressure vessel unsafe					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	5		4	2
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u> (see above)					
2. <u>Light to moderate damage:</u> (see above)	3	2	2	20	3
3. <u>Moderate to heavy damage:</u> (see above)	6	5	4	120	20
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	5	4		6	2
PAGE 2D-2	STATIONARY HEAVY-WALLED/PRESSURE VESSELS				

TYPE: HEAVY-WALLED PROCESSING VESSELS

EQUIPMENT PAGE NO. 2D-3

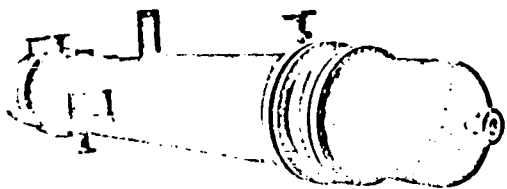
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

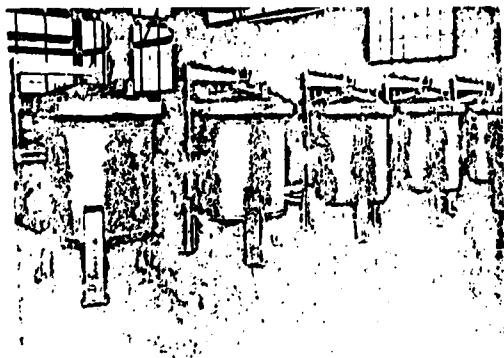
Autoclaves

Reactors

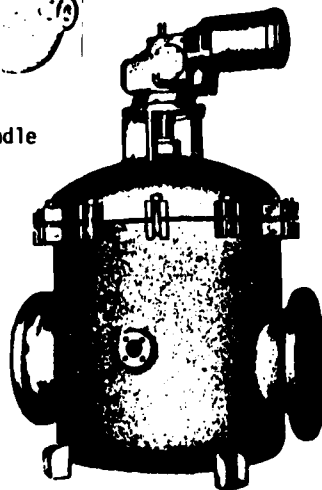
Strainers



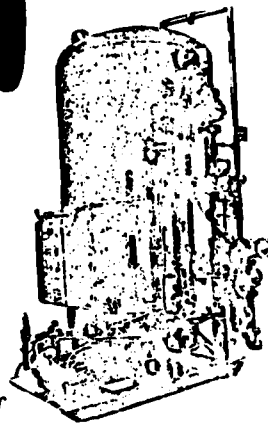
Heat Exchangers with Removable Bundle



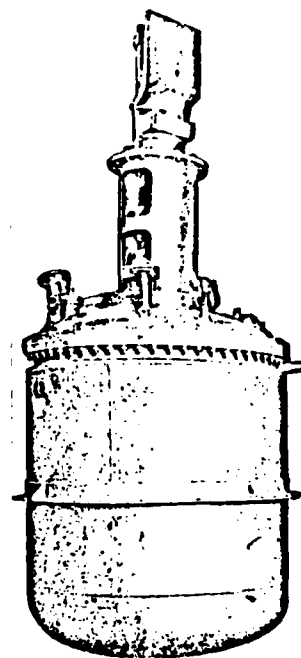
Vertical Lift Autoclaves 48" Diameter



High Pressure Strainer



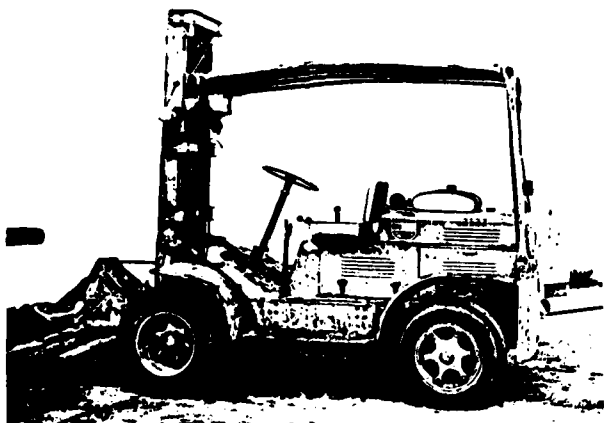
Demineralizer



Autoclave for Low Pressure Synthesis

GROUP: 2D-3 HEAVY-WALLED PROCESSING VESSELS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		FULL	EMPTY			
1. <u>Little or no damage:</u> Light instrumentation damage						
2. <u>Light to moderate damage:</u> Light components heavily damaged; piping damaged and leaking at connections		3	2	2	8	1
3. <u>Moderate to heavy damage:</u> Heavy piping & accessory damage; frame/supports distorted; unit displaced from foundation.		6	5	4	16	3
4. <u>Destroyed:</u> Vessel unsafe/unusable						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	3		3	< 1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		3	2	2	10	2
3. <u>Moderate to heavy damage:</u>		5	4	4	24	4
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	3		4	< 1
PAGE 2D-3		HEAVY-WALLED PROCESSING VESSELS				

TYPE: MOBILE MECHANICAL HANDLING EQUIPMENT (POTENTIAL RESOURCE) EQUIPMENT PAGE NO. 2E-1
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

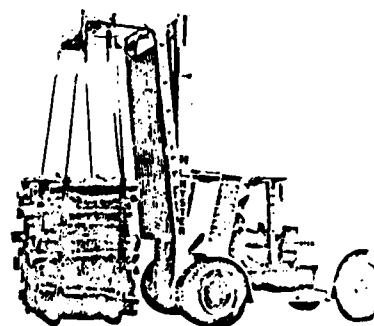


Forklift

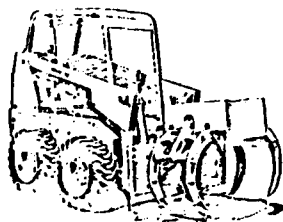
EXAMPLES

Loaders

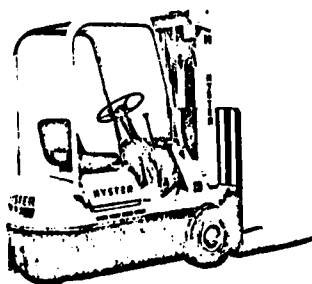
Forklifts



Pulpwood Loader



Loader



Lift Trucks



Forklift

GROUP: 2E-1 MOBILE MECHANICAL HANDLING EQUIPMENT	BLAST LEVEL (PST)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u> Controls damaged; covers & panels dented and/or blown off; unprotected accessories damaged by deflecting covers/missiles	3	2	2	8	1
3. <u>Moderate to heavy damage:</u> Tires punctured by missiles; heavy blast damage to flat surfaces; glass broken; heavy control damage; breakables fractured; engine accessories damaged/broken	5	3	3	16	3
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3		3	1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>					
3. <u>Moderate to heavy damage:</u>					
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 2E-1	MOBILE MECHANICAL HANDLING EQUIPMENT.				

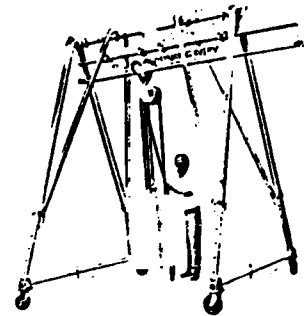
TYPE: MOVABLE/LIMITED/TRACKED HANDLING EQUIPMENT

EQUIPMENT PAGE NO. 2E-2

Maximum Dimensions: (15x15x20) Feet - Maximum Weight: 30,000 Pounds

EXAMPLES

Bridge Cranes
Monorail Cranes
Balance Arms



Gantry

GROUP: 2E-2 MOVABLE/LIMITED/TRACKED HANDLING EQUIPMENT

DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u> Covers & panels bent/buckled and/or torn off; electrical components broken; wiring damaged	3	2	2	6	1
3. <u>Moderate to heavy damage:</u> Equipment off tracks; motors demounted/misaligned; piping broken at connections; some structural damage; some castings broken	5	4	3	24	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3		8	1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2	2	2	8	1
3. <u>Moderate to heavy damage:</u>	4	3	3	32	4
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	3		8	1

TYPE: STATIONARY MATERIAL HANDLING EQUIPMENT

EQUIPMENT PAGE NO. 2E-3

Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

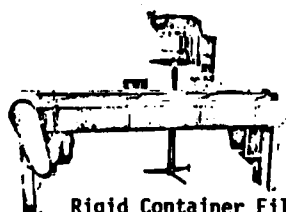
Conveyors

Can/Bottle Handlers and Fillers

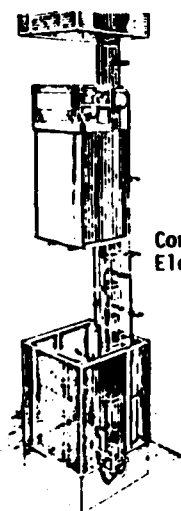
Material Elevators



Shaker Conveyor

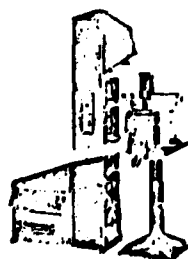


Rigid Container Filling Machine



Construction
Elevator

Product Elevator



Counter Feeder



Form, Fill, Seal,
Bag Machine

GROUP: 2E-3 STATIONARY MATERIAL HANDLING EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u> Covers & plates & panels bent or buckled; misalignment of light frame members; breakable components fractured; wiring damaged		2	1	2	8	1
3. <u>Moderate to heavy damage:</u> Motors and drives misaligned; light frame members heavily damaged; extensive control damage; electrical components very heavily damaged; units displaced on foundations.		6	3	4	16	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	2		8	1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		2	1	2	8	1
3. <u>Moderate to heavy damage:</u>		4	3	4	16	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	2		8	1
PAGE 2E-3		STATIONARY MATERIAL HANDLING EQUIPMENT				

SIMPLE REFRACTORY CONSTRUCTIONS

EQUIPMENT PAGE NO. 2F-1

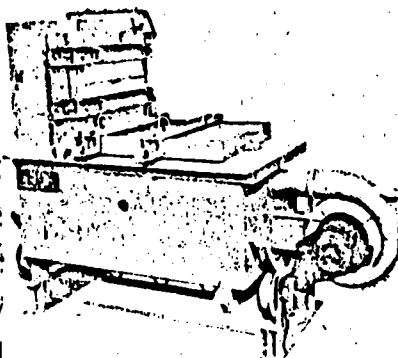
TYPE: Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds

EXAMPLES

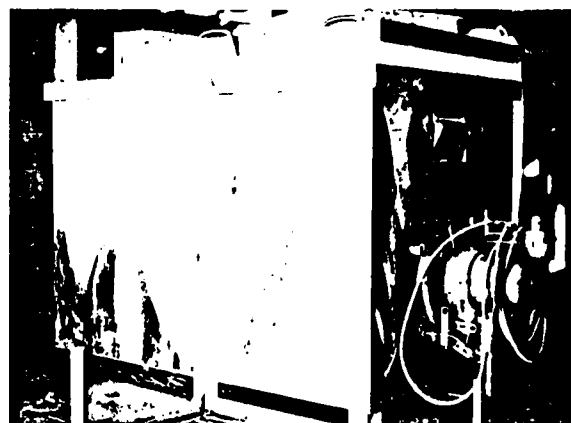
Box Type Furnaces
Ovens



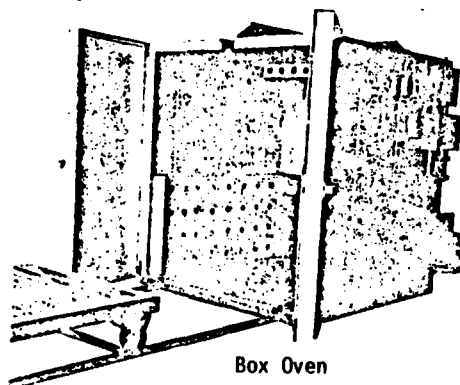
Box Oven



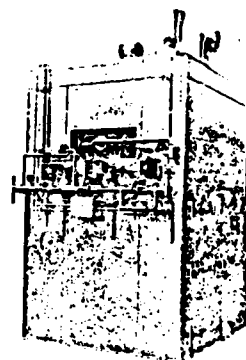
Reverberatory Furnace



Box Oven



Box Oven



Preheating Oven

GROUP: 2F-1 SIMPLE REFRACTORY CONSTRUCTIONS		BLAST LEVEL (PSI)		RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
1. <u>Little or no damage:</u> Light cracking					
2. <u>Light to moderate damage:</u> Some cracking and brick loss	1.5		1.5	8	1
3. <u>Moderate to heavy damage:</u> Heavy cracking and refractory damage; some walls fail; doors & access assemblies damaged; accessories damaged; instrumentation broken	3		2	16	2
4. <u>Destroyed:</u> Structure destroyed or unsafe					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2			4	1
DAMAGE DESCRIPTION VERTICAL CONFIGURATION (H/B > 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	1		1	12	1
3. <u>Moderate to heavy damage:</u>	2		2	24	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2			4	1
PAGE 2F-1		SIMPLE REFRACTORY CONSTRUCTIONS			

TYPE: REFRACTORY LINED EQUIPMENT

EQUIPMENT PAGE NO. 2F-2

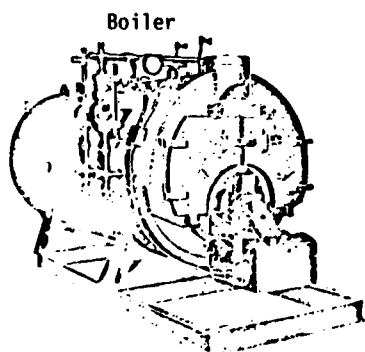
Maximum Dimensions: (15x15x20) Feet — Maximum Weight: 30,000 Pounds



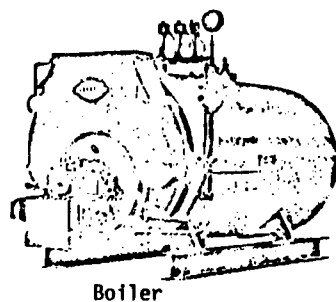
STEEL SHELL FURNACE

EXAMPLES

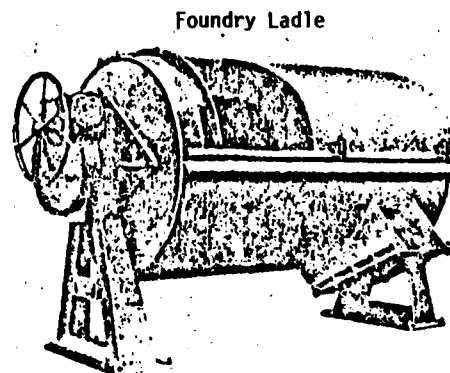
Boilers
Arc and Induction Furnaces
Stacks to 30 ft
Small Calciners
Ladles



Boiler



Boiler



Foundry Ladle

GROUP: 2F-2 REFRACTORY-LINED EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Some refractory cracking						
2. <u>Light to moderate damage:</u> Unprotected or unbacked refractory heavily damaged; other refractory cracked; accessories damaged; panels & covers damage components		2	1	2	8	1
3. <u>Moderate to heavy damage:</u> Refractory lining needs extensive repair or replacement		4	2	3	48	3
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	2		6	1
VERTICAL CONFIGURATION (H/B > 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		2	1	1	12	1
3. <u>Moderate to heavy damage:</u>		3	2	2	48	3
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	2		6	1
PAGE 2F-2		REFRACTORY-LINED EQUIPMENT				

VULNERABILITY RATINGS

GROUP 3

TYPE:

ASSEMBLIES AND LIGHT FRAME CONSTRUCTIONS

EQUIPMENT PAGE NO.

3A-1

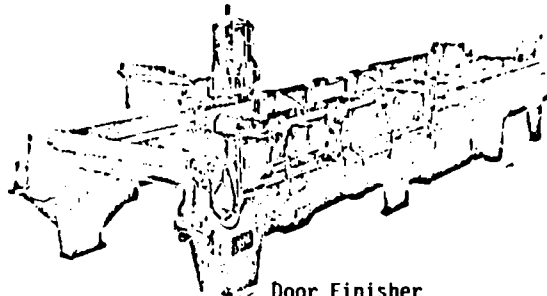
Minimum Dimensions: (15x15x20) feet - Minimum Weight: 30,000 Pounds

EXAMPLES

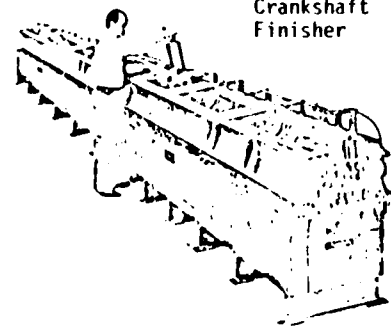
Printing Presses

Looms

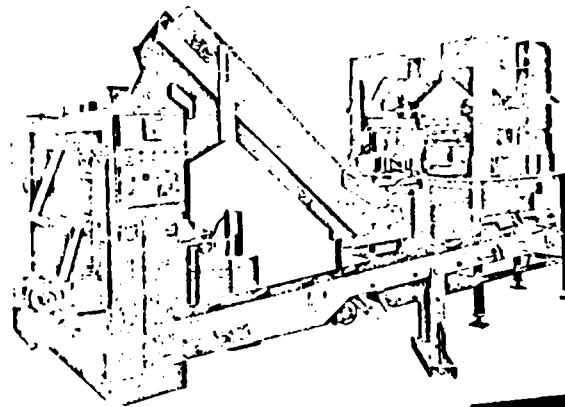
Compactor



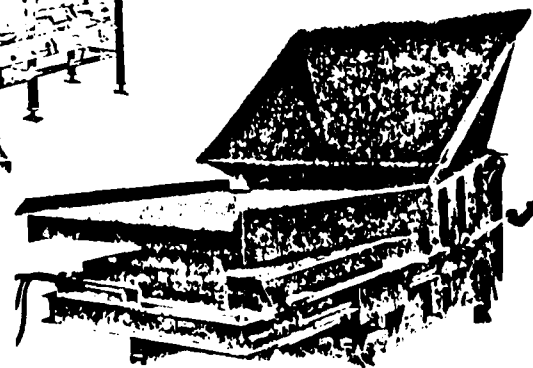
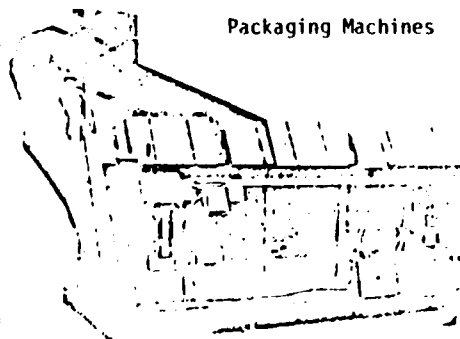
Door Finisher



Crankshaft
Finisher



Packaging Machines



Compactor

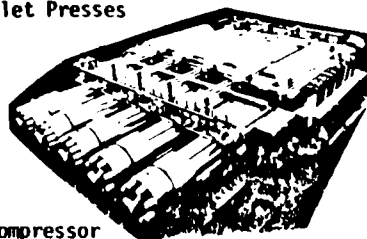
GROUP: 3A-1 ASSEMBLIES AND LIGHT FRAME CONSTRUCTIONS	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
HORIZONTAL CONFIGURATION (H/B ≤ 2)					
1. <u>Little or no damage:</u> Covers bent; some wiring damage & broken glass					
2. <u>Light to moderate damage:</u> Covers and panels wrecked; wiring and small piping damaged; controls & instrumentation smashed; breakables fractured	3	2	2	32	4
3. <u>Moderate to heavy damage:</u> Motors damaged & misaligned; frame damaged; electrical components heavily damaged; piping and wiring torn off.	5	4	3	160	15
4. <u>Destroyed:</u> Replacement required					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3		4	1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u> (see above)					
2. <u>Light to moderate damage:</u> (see above)	2	2	2	32	5
3. <u>Moderate to heavy damage:</u> (see above)	5	4	3	240	24
4. <u>Destroyed:</u> (see above)					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3		4	1
PAGE 3A-1	ASSEMBLIES AND LIGHT FRAME CONSTRUCTIONS				

TYPE: HEAVY FRAME EQUIPMENT
Minimum Dimensions : (15x15x20) Feet — Minimum Weight: 30,000 Pounds

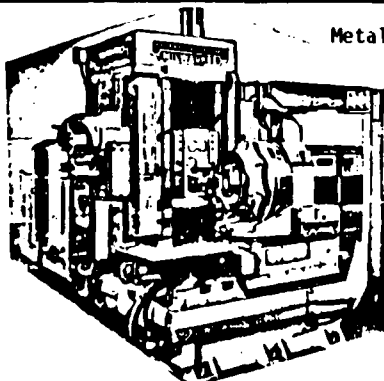
EQUIPMENT PAGE NO. 3A-2

EXAMPLES

Large Presses
Large Forges
Slab/Billet Presses



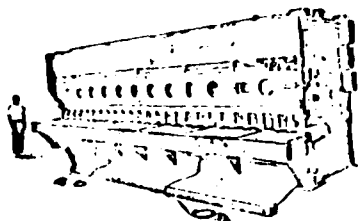
High Pressure Compressor



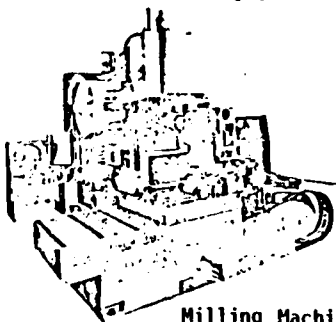
Metal Turning Center



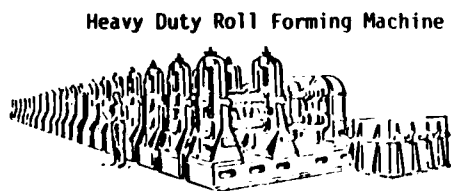
Plastic Molding Machine



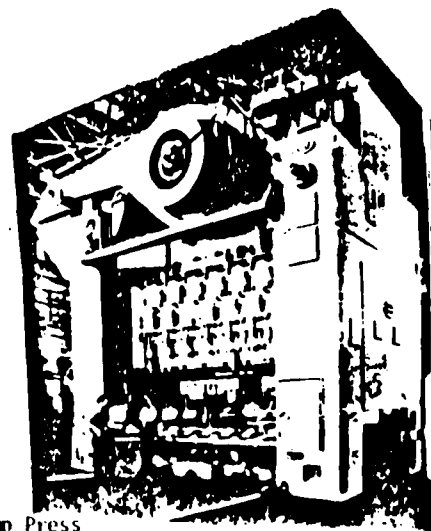
Heavy Shear



Milling Machine



Heavy Duty Roll Forming Machine



Stamp Press

GROUP: 3A-2 HEAVY FRAME EQUIPMENT

DAMAGE DESCRIPTION	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
HORIZONTAL CONFIGURATION (H/B \leq 2)					
1. <u>Little or no damage:</u> Covers bent; light accessories damaged					
2. <u>Light to moderate damage:</u> Covers torn off; wiring damaged; some control and accessory damage; instruments heavily damaged.	3	2	2	32	2
3. <u>Moderate to heavy damage:</u> Instruments destroyed; controls and accessories heavily damaged; some frame damage; piping torn loose.	8	4	3	60	4
4. <u>Destroyed:</u> Replacement necessary					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	6	3		3	1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	4	2	2	36	3
3. <u>Moderate to heavy damage:</u>	6	3	3	72	6
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	5	3		4	1
PAGE 3A-2	HEAVY FRAME EQUIPMENT				

TYPE: POWER GENERATION EQUIPMENT

EQUIPMENT PAGE NO. 3B-1

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

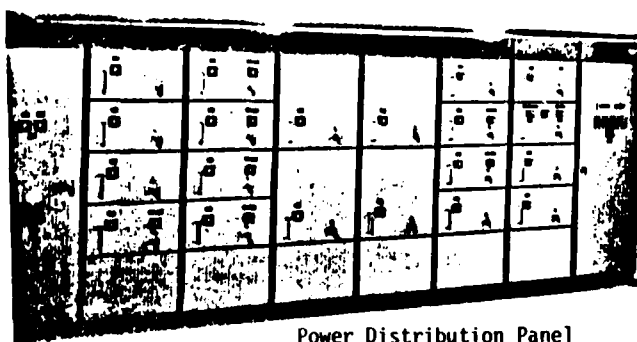


GROUP: 3B-1 POWER GENERATION EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Covers bent/blown off; Gauges broken						
2. <u>Light to moderate damage:</u> Covers and guards blown into wiring; plastic components broken; instruments and uncovered accessories damaged		6	5	4	12	3
3. <u>Moderate to heavy damage:</u> Exposed conduits torn from terminations; wiring heavily damaged; some frame damage may occur.		12	8	6	120	10
4. <u>Destroyed:</u> Replacement necessary						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		9	7		3	< 1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		4	4	4	16	3
3. <u>Moderate to heavy damage:</u>		8	6	6	120	10
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		6	5		3	< 1
PAGE 3B-1		POWER GENERATION EQUIPMENT				

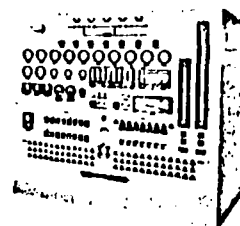
TYPE: HEAVY FRAMED RACKS, PANEL, ENCLOSED EQUIPMENT PAGE NO. 3B-2
Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EXAMPLES

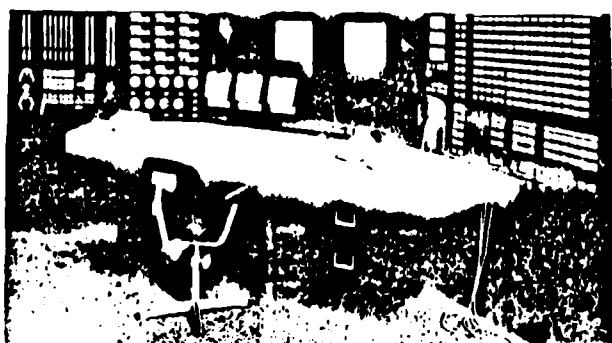
Main Distribution Panels



Power Distribution Panel



Control Panels



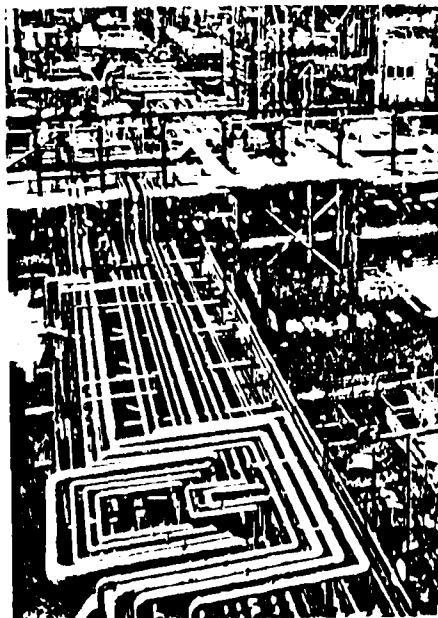
Control Station

GROUP: 3B-2 HEAVY-FRAMED RACKS, PANEL, ENCLOSED		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>						
3. <u>Moderate to heavy damage:</u>						
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING						
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u> Glass broken; some covers bent						
2. <u>Light to moderate damage:</u> Covers bent & blown into components; some plastic electrical components broken; Instrumentation suffers broken external components & loss of calibration		2	1	1	24	3
3. <u>Moderate to heavy damage:</u> External panels heavily damaged and driven against internal components; broken external controls; extensive internal damage		4	2	2	48	5
4. <u>Destroyed:</u> Replacement required						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	2		1 hr/linear foot	
PAGE 3B-2		HEAVY-FRAMED RACKS, PANEL, ENCLOSED				

TYPE: UTILITY DISTRIBUTION EQUIPMENT
Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EQUIPMENT PAGE NO. 3B-3

EXAMPLES
Piping Arrays



Piping Array

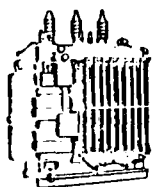
GROUP: 3B-3 UTILITY DISTRIBUTION EQUIPMENT

GROUP: 3B-3 UTILITY DISTRIBUTION EQUIPMENT	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
HORIZONTAL CONFIGURATION (H/B ≤ 2)					
1. <u>Little or no damage:</u> Some deformation of piping and bus covers					
2. <u>Light to moderate damage:</u> Breakage of some electrical components; many fasteners broken with much pipe deformation; air lines suffer cracks; some electrical conductors damaged.	3	2	3	3 hr/100 ft	
3. <u>Moderate to heavy damage:</u> Many pipes torn from mounts & terminations; buses heavily damaged; insulators & standoffs broken.	6	3	4	10 hr/100 ft	
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
	5	3		1 hr/100 ft	
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2	2	2	4 hr/100 ft	
3. <u>Moderate to heavy damage:</u>	4	3	3	15 hr/100 ft	
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
	3	3		2 hr/100 ft	
PAGE 3B-3 UTILITY DISTRIBUTION EQUIPMENT					

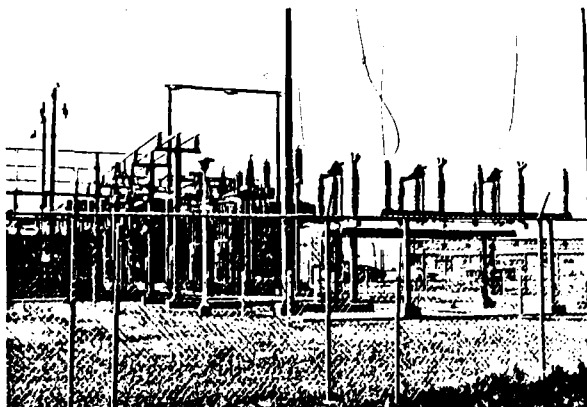
TYPE: SUBSTATION-TYPE EQUIPMENT

EQUIPMENT PAGE NO. 3B-4

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds



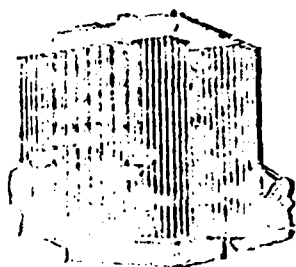
10 MVA Power Transformer



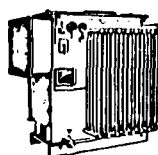
Transformers and Switchgear

EXAMPLES

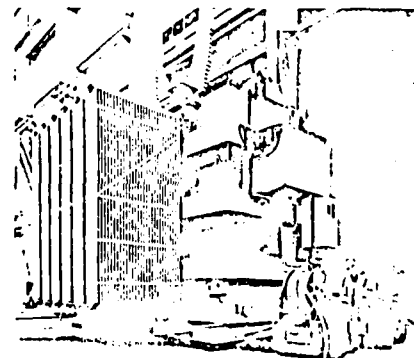
MVA Class Breakers
Main Transformers



MVA Class
Transformer



Load Center
Transformer



Transformer

Group: 3B-4 SUBSTATION-TYPE EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION	HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Some insulator damage from missiles; cooling radiators deformed						
2. <u>Light to moderate damage:</u> Radiators damaged & leaking; wiring torn loose; missile punctures in some casings.		5	3	3	14	3
3. <u>Moderate to heavy damage:</u> Power connections broken; heavy insulator breakage; sides of transformers & circuit breakers distorted & ruptured; some overturning of components.		8	6	5	48	8
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		7	5		3	1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		4	2	2	16	3
3. <u>Moderate to heavy damage:</u>		7	5	3	48	8
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		6	4		4	1
PAGE 3B-4		SUBSTATION-TYPE EQUIPMENT				

TYPE:

MATERIAL STORAGE UNITS

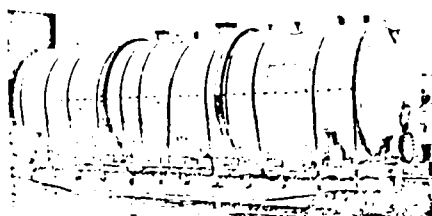
EQUIPMENT PAGE NO. _____

3C-1

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EXAMPLES

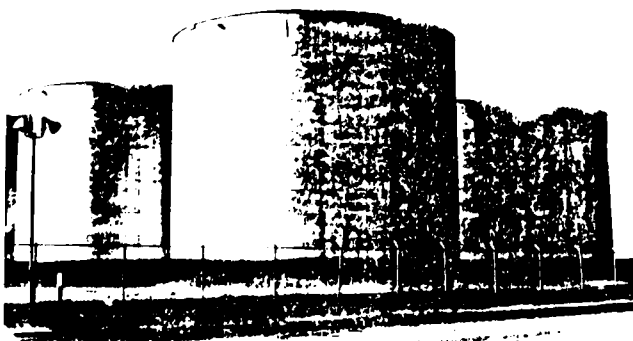
Large Bins
Tanks



Dewatering Tank



Storage Tanks



Storage Tanks

GROUP: 3C-1 MATERIAL STORAGE UNITS	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	FULL	EMPTY			
1. <u>Little or no damage:</u> Some distortion of side walls					
2. <u>Light to moderate damage:</u> Some leakage; plates bent or buckled; sides knocked in.	3	1	1	8	1
3. <u>Moderate to heavy damage:</u> Piping broken loose; substantial leakage; some separation from foundation/frame.	5	1.5	1.5	24	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	1.5		3	1
VERTICAL CONFIGURATION (H/B > 2)					
1. <u>Little or no damage:</u>					
2. <u>Light to moderate damage:</u>	2	1	1	12	1
3. <u>Moderate to heavy damage:</u>	4	1.5	1.5	36	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3	1		4	1
PAGE 3C-1	MATERIAL STORAGE UNITS				

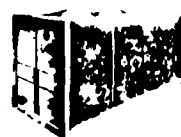
TYPE: LIGHT-WALLED ELEVATED CONSTRUCTIONS
Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EQUIPMENT PAGE NO. 3C-2

EXAMPLES

Baghouses
Large Hoppers
Cooling Towers
Chillers

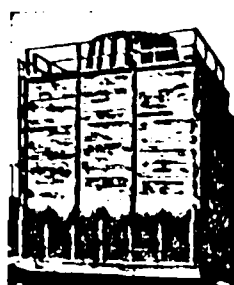
Chiller



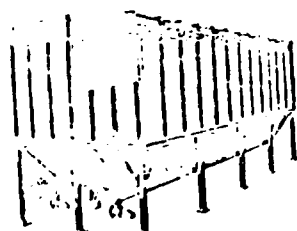
Evaporator Condenser



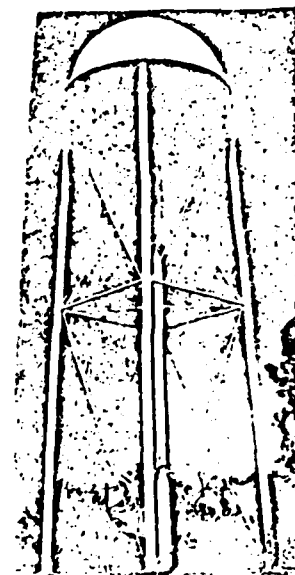
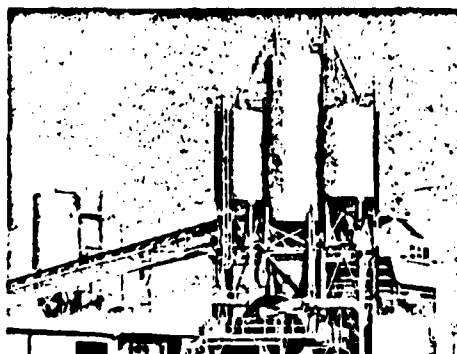
Cooling Tower



Dust Recovery Pulsejet Filter
Collection Units



Elevated Steel Tanks



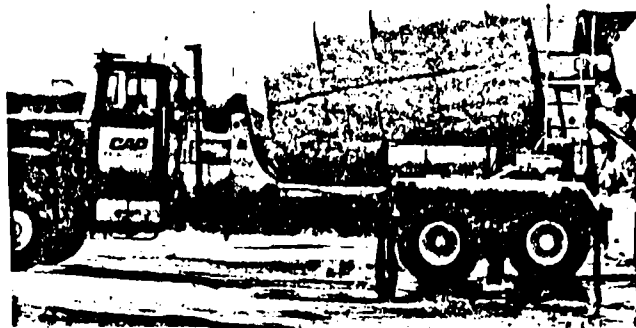
GROUP: 3C-2 LIGHT-WALLED ELEVATED CONSTRUCTIONS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		FULL	EMPTY			
1. <u>Little or no damage:</u> Some side wall damage						
2. <u>Light to moderate damage:</u> Sides bent/buckled; supporting structure slightly damaged; breakable parts fractured; light fan housings deformed.	2		1	1	8	1
3. <u>Moderate to heavy damage:</u> Frame distorted/buckled; fans destroyed; electrical components broken; pipe connections damaged; light internal components damaged by buckled walls supporting structure deformed.	4		2	2	32	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		3	2		3	1
DAMAGE DESCRIPTION VERTICAL CONFIGURATION (H/B > 2)		FULL	EMPTY	MISSILES	MANHOURS	DAYS
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>						
3. <u>Moderate to heavy damage:</u>						
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING						
PAGE 3C-2		LIGHT-WALLED ELEVATED CONSTRUCTIONS				

TYPE: HEAVY-WALLED VESSELS, MOBILE (POTENTIAL RESOURCE)
Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

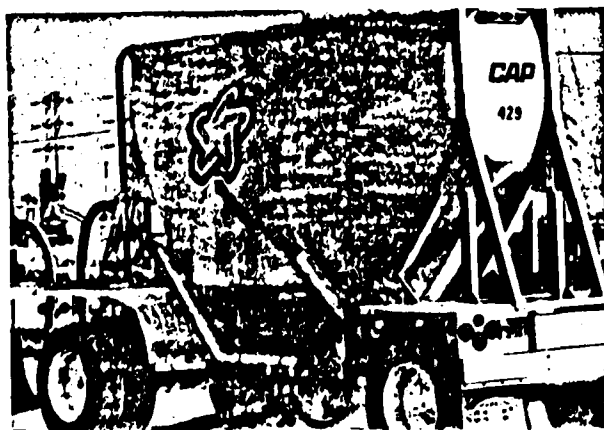
EQUIPMENT PAGE NO. 3D-1

EXAMPLES

Mobile Heavy Wall Vessels
Pressure Vessels



Mobile Heavy Wall Vessels

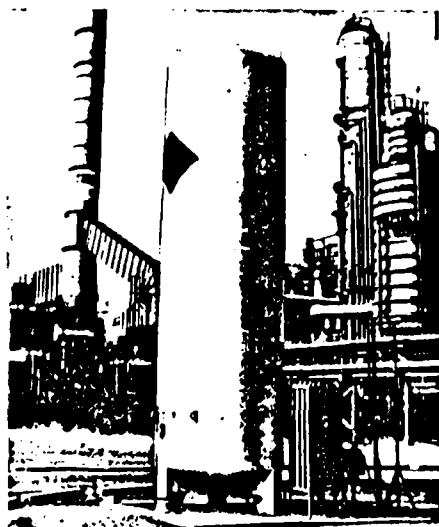


GROUP: 3D-1 HEAVY-WALLED VESSELS, MOBILE (POTENTIAL RESOURCE)		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Light accessories damaged						
2. <u>Light to moderate damage:</u> Controls damaged; breakable components fractured; rubber tires damaged by missiles.		4	n/a	3	8	1
3. <u>Moderate to heavy damage:</u> Controls & accessories heavily damaged; tank displaced from mounts; piping broken from connections.		6		4	12	1
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5			4	1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>						
3. <u>Moderate to heavy damage:</u>						
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING						
PAGE 3D-1		HEAVY-WALLED VESSELS, MOBILE (POTENTIAL RESOURCE)				

TYPE: HEAVY-WALLED LIQUID/GAS STORAGE VESSELS
Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EQUIPMENT PAGE NO. 3D-2

EXAMPLES
Special Tank
LPG Storage



LPG Storage



Special Tank

GROUP: 3D-2 HEAVY-WALLED LIQUID/GAS STORAGE VESSELS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		FULL	EMPTY			
1. <u>Little or no damage:</u> Some instrumentation damage						
2. <u>Light to moderate damage:</u> Light components damaged (panels, covers, etc.); some pipes & connections damaged; missile damage to external components.		4	3	2	8	1
3. <u>Moderate to heavy damage:</u> Piping damaged; some side wall damage; frame & supports distorted; some anchors broken; heavy missile damage to external components.		6	5	4	16	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	4		6	1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		3	2	2	12	1
3. <u>Moderate to heavy damage:</u>		6	5	4	20	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	4		6	1
PAGE 3D-2		HEAVY-WALLED LIQUID/GAS STORAGE VESSELS				

TYPE: HEAVY-WALLED PROCESSING VESSELS

EQUIPMENT PAGE NO. 3D-3

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

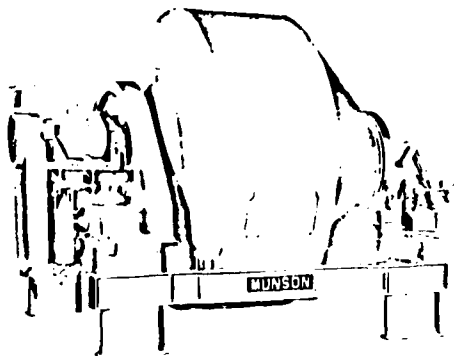
EXAMPLES

Autoclaves

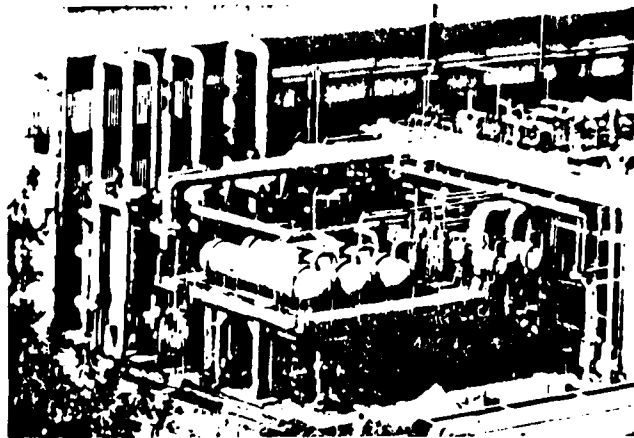
Reactors

"Cat" Crackers

High Pressure Processing Equipment



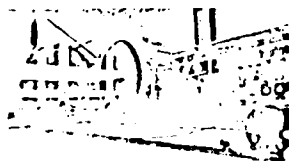
Rotary Batch Mixer



High Pressure Processing Equipment



Autoclaves



Heat Exchanger

GROUP: 3D-3 HEAVY-WALLED PROCESSING VESSELS		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		FULL	EMPTY			
1. <u>Little or no damage:</u> Light instrumentation damage.						
2. <u>Light to moderate damage:</u> Light components heavily damaged; piping damaged and leaking at connections.		3	2	2	8	1
3. <u>Moderate to heavy damage:</u> Heavy piping damage; frame/supports distorted; unit displaced off foundation.		6	4	4	20	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	3		4	1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		3	2	2	12	1
3. <u>Moderate to heavy damage:</u>		4	4	4	24	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	3		5	1

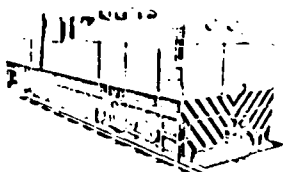
PAGE 3D-3

HEAVY-WALLED PROCESSING VESSELS

TYPE: MOBILE MATERIAL HANDLING EQUIPMENT (POTENTIAL RESOURCES)

EQUIPMENT PAGE NO. 3E-1

Minimum Dimensions: (15x15x20) Feet - Minimum Weight: 30,000 Pounds



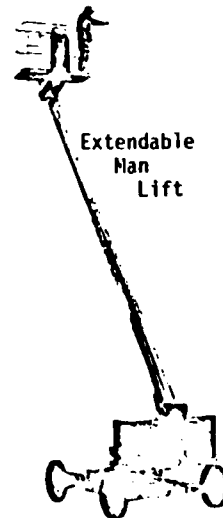
Locomotive



Self-Propelled Telescopic
Car Loader

EXAMPLES

Locomotives
Large Trucks
Carriers



Extendable
Man
Lift

GROUP: 3E-1 MOBILE MATERIAL HANDLING EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Covers & guards bent; glass broken; loosely fitting particles blown away.						
2. <u>Light to moderate damage:</u> Electrical equipment damaged; wiring torn loose; covers, guards & panels heavily damaged; instrumentation destroyed; controls damaged; lightly constructed items bent & broken.		4	2	2	24	2
3. <u>Moderate to heavy damage:</u> Damage to heavy welded parts; some broken castings; severe motor damage; controls broken; cabling and piping torn off.		6	5	3	48	4
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	4		4	1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		3	2	2	32	2
3. <u>Moderate to heavy damage:</u>		6	4	3	52	6
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	3		4	1
PAGE 3E-1		MOBILE MATERIAL HANDLING EQUIPMENT				

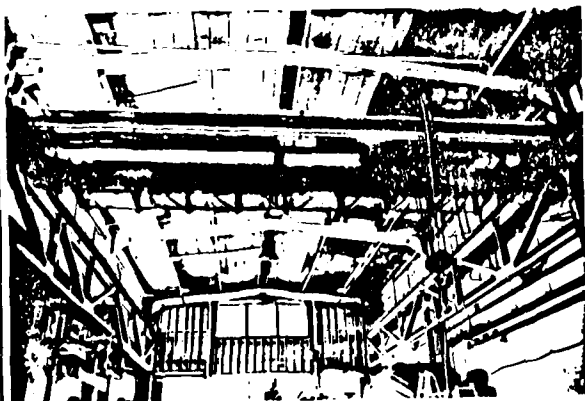
MOVABLE/TRACKED MATERIAL HANDLING EQUIPMENT

EQUIPMENT PAGE NO. 31-2

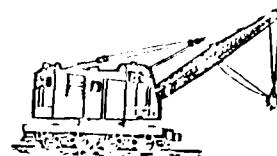
TYPE: Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EXAMPLES

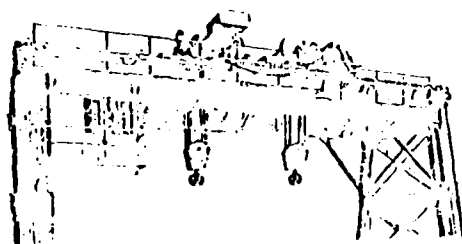
Large Bridge Cranes
Monorail Cranes
Rail Car Dumpers



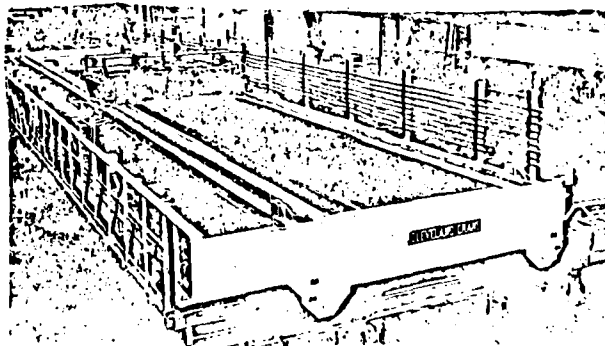
Bridge Crane



Tracked Crane



Tracked Crane



Overhead Crane

GROUP: 3E-2 MOVABLE/TRACKED MATERIAL HANDLING EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
HORIZONTAL CONFIGURATION (H/B ≤ 2)						
1. <u>Little or no damage:</u> Wiring & buses damaged; covers bent/blown off; glass broken.						
2. <u>Light to moderate damage:</u> Wiring and buses heavily damaged; motors damaged; instrumentation broken; piping damaged; controls & accessories broken.		4	3	2	32	3
3. <u>Moderate to heavy damage:</u> Structural damage; wheels & tracks misaligned; motors misaligned & heavily damaged; controls destroyed; instrumentation and accessories destroyed.		8	5	3	48	4
4. <u>Destroyed:</u> Replacement required.						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		6	4		4	2
VERTICAL CONFIGURATION (H/B > 2) OR ELEVATED						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		3	2	2	36	3
3. <u>Moderate to heavy damage:</u>		6	4	3	56	4
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		5	3	3	4	2
PAGE 3E-2		MOVABLE/TRACKED MATERIAL HANDLING EQUIPMENT				

TYPE: STATIONARY MATERIAL HANDLING EQUIPMENT

EQUIPMENT PAGE NO. 3E-3

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EXAMPLES

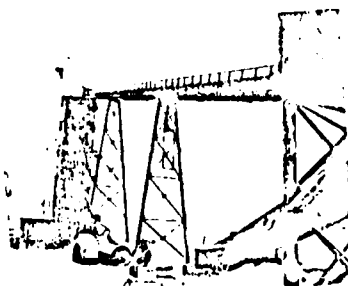
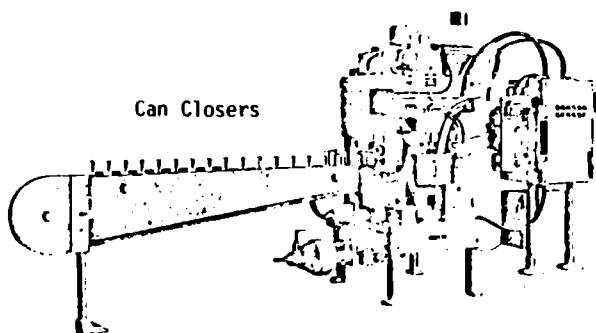
Can Feeders

Conveyors

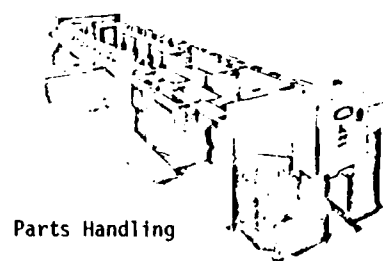
Material Elevators

Grease Slides

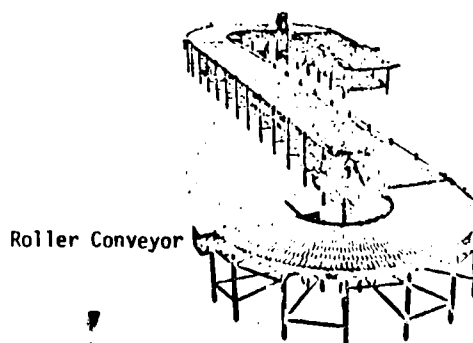
Can Closers



Belt Conveyor



Parts Handling



Roller Conveyor

GROUP: 3E-3 STATIONARY MATERIAL HANDLING EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS	
	SECURED	NOT SECURED				
1. <u>Little or no damage:</u> Some panels & covers bent						
2. <u>Light to moderate damage:</u> Missiles and buckling covers break some components; some mechanical misalignment; light frames distort.	3	2	2	8	1	
3. <u>Moderate to heavy damage:</u> Feed screws, rollers, moving parts jammed/misaligned; light components heavily damaged; motors & wiring damaged; anchor bolts & fasteners broken.	6	3	3	12	1	
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3	3	3	1	
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>	3	2	2	12	1	
3. <u>Moderate to heavy damage:</u>	4	3	4	16	2	
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	4	3		4	1	
PAGE 3E-3		STATIONARY MATERIAL HANDLING EQUIPMENT				

TYPE: SIMPLE REFRACTORY CONSTRUCTIONS

EQUIPMENT PAGE NO.

3F-1

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

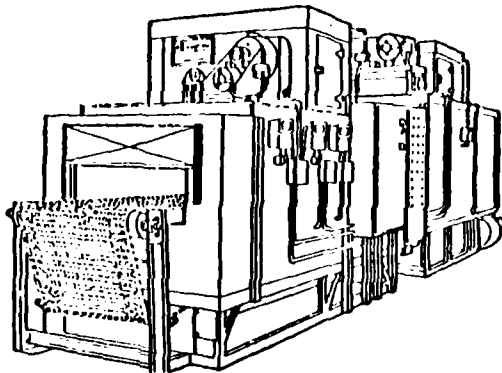
EXAMPLES

Box-Type Furnaces

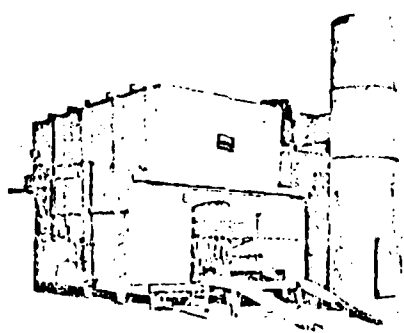
Ovens

Masonry Buildings and vaults

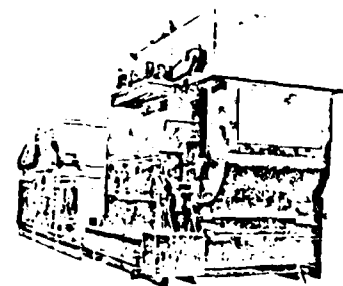
Continuous Oven



Oven



Box Furnace



Process Oven

GROUP: 3F-1 SIMPLE REFRACTORY CONSTRUCTIONS	BLAST LEVEL (PSI)			RECOVERY	
	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		NOT SECURED			
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2) 1. <u>Little or no damage:</u> Some distortion & damage of light components. 2. <u>Light to moderate damage:</u> Doors distorted & knocked from tracks/hinges; some masonry cracks & loose bricks; some block damage. 3. <u>Moderate to heavy damage:</u> Parts of masonry/brickwork blown down; accessories damaged; some walls fail; many blocks/bricks fractured; doors wrenched loose. 4. <u>Destroyed:</u> Bricks/blocks broken & turned into missiles.	2	n/a	1	8	1
	3		3	16	2
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	3			4	1
VERTICAL CONFIGURATION (H/B > 2) 1. <u>Little or no damage:</u> 2. <u>Light to moderate damage:</u> 3. <u>Moderate to heavy damage:</u> 4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 3F-1	SIMPLE REFRACTORY CONSTRUCTIONS				

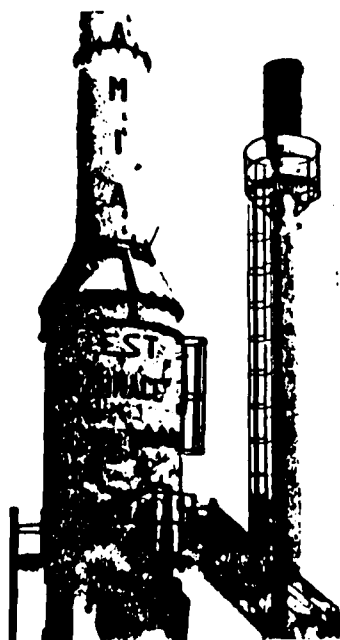
TYPE: REFRACTORY-LINED EQUIPMENT

EQUIPMENT PAGE NO. 3F-2

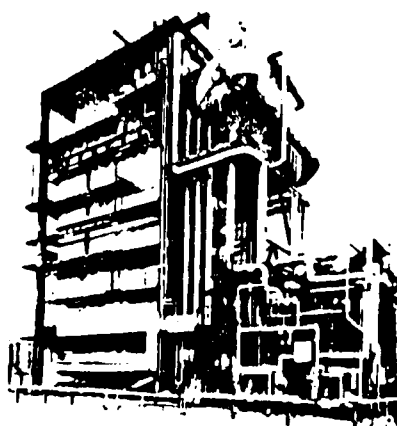
Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

EXAMPLES

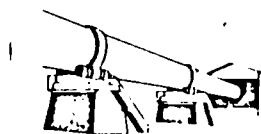
Boilers
Arc and Induction Furnaces
Calciners



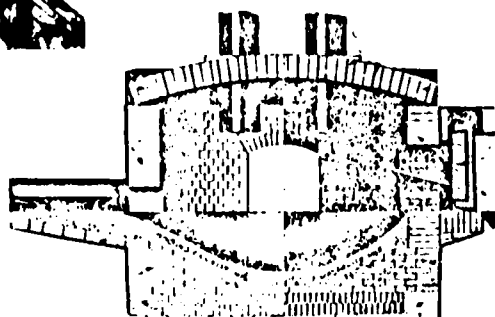
R & D Furnace



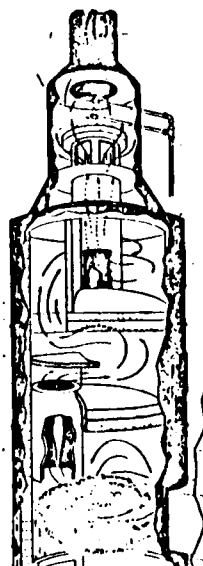
Boiler



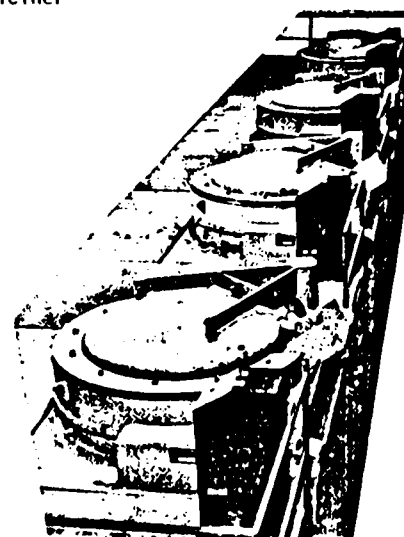
Calciner



Electric Arc Furnace



Incinerator



Induction Furnace

GROUP: 3F-2 REFRACTORY-LINED EQUIPMENT		BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION HORIZONTAL CONFIGURATION (H/B ≤ 2)		BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
		SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Instrumentation damaged; covers & panels bent/buckled.						
2. <u>Light to moderate damage:</u> Instrumentation broken; some refractory damage; flues damaged; boiler sides distorted; fans & housings damaged.		3	2	2	8	1
3. <u>Moderate to heavy damage:</u> Heavy refractory damage; instrumentation destroyed; piping & connections broken; equipment displaced from mountings; stacks & flues heavily damaged or destroyed.		6	4	4	16	2
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		6	3		6	1
VERTICAL CONFIGURATION (H/B > 2)						
1. <u>Little or no damage:</u>						
2. <u>Light to moderate damage:</u>		2	1.5	2	8	1
3. <u>Moderate to heavy damage:</u>		4	3	3	32	3
4. <u>Destroyed:</u>						
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING		4	2		6	1
PAGE 3F-2		REFRACTORY-LINED EQUIPMENT				

STACKS

TYPE:

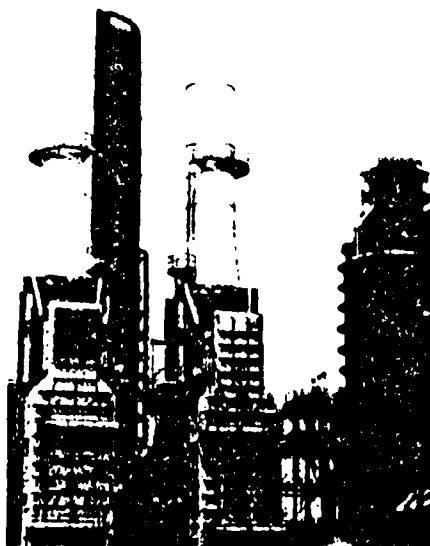
EQUIPMENT PAGE NO.

3F-3

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

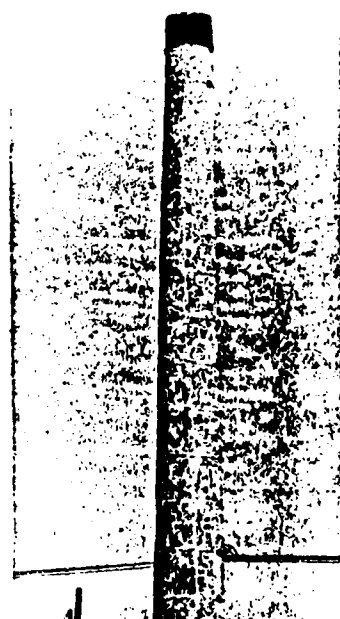
EXAMPLES

Exhaust Stacks
Concrete Silos
Distillation Towers
Cat Crackers
Metal Stacks
Petroleum Processing Towers
Reduction Column



Exhaust Stacks

Reduction Column



Masonry Stack

GROUP: 3F-3 STACKS

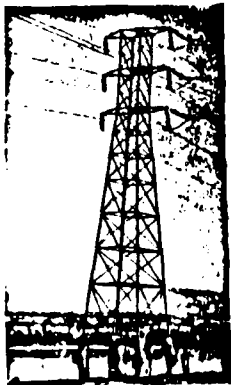
DAMAGE DESCRIPTION	BLAST LEVEL (PSI)		RECOVERY	
	BLAST w/o MISSILES		MANHOURS	DAYS
		MISSILES		
1. <u>Little or no damage:</u> Crack appear — most damage due to wind loads & drag effects which increase with blast psi.				
2. <u>Light to moderate damage:</u> Some breakage of masonry; many large & significant cracks rend structure.	0.5	0.5	8	1
3. <u>Moderate to heavy damage:</u> Possible truncation of stack; substantial masonry damage/brick breakage; structure may be unstable	1.5	n/a	12	1
4. <u>Destroyed:</u>				
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	1.5		4	1
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING				
PAGE 3F-3	STACKS			

TYPE: METAL TOWERS AND ASSEMBLIES

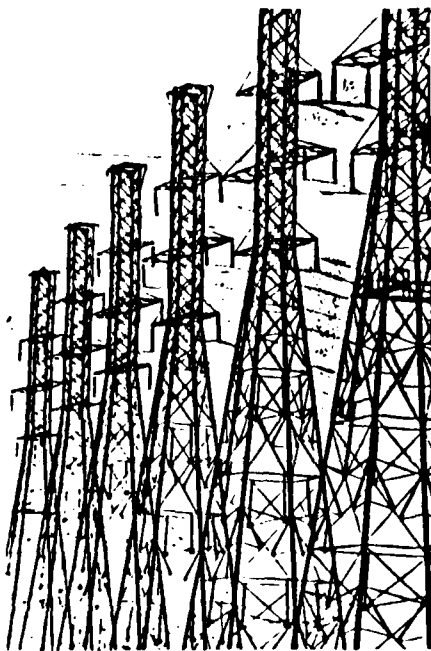
EQUIPMENT PAGE NO.

3G-1

Minimum Dimensions: (15x15x20) Feet — Minimum Weight: 30,000 Pounds

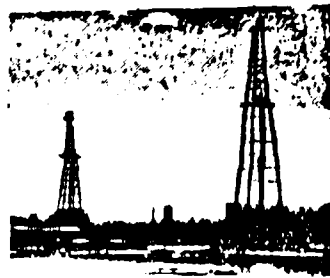


Transmission Towers



EXAMPLES

Transmission Towers
Scaffolding
Catwalks
Oil Derricks



Oil Derricks



Tower

GROUP: 3G-1 METAL TOWERS & ASSEMBLIES	BLAST LEVEL (PSI)			RECOVERY	
DAMAGE DESCRIPTION	BLAST w/o MISSILES		MISSILES	MANHOURS	DAYS
	SECURED	NOT SECURED			
1. <u>Little or no damage:</u> Some distortion of covers of antennas					
2. <u>Light to moderate damage:</u> Covers blown off dish antennas; antennas disoriented; long wire antennas may fail; some distortion.	1	0.5	1	8	1
3. <u>Moderate to heavy damage:</u> Long wire antennas down; dish antennas damaged; columns deformed	2	1	1	16	2
4. <u>Destroyed:</u>					
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING	2	1		4	1
SURVIVAL BLAST RATING WITH PROTECTIVE HOUSEKEEPING					
PAGE 3G-1	METAL TOWERS & ASSEMBLIES				

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 8B

EQUIPMENT INDEX

This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

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		3A-2
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EQUIPMENT INDEX

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	Planers	
	Presses	
	Profile finishing machine	1A-3
	Reaming machine	2A-2
	Rifling machine	3A-2
	Sander	
	Saws	
	Shaper	
	Shaving machine	
	Slotting & milling machine	
	Speed lathe	
	Surface polishers	
	Tapping machine	
	Threading machine	
	Woodworking equipment	
Metal Forming Equipment	Bender	
	Dimpling machine	
	Embossing "	
	Erecting plate	1A-3
	Expanding machine	2A-2
	Extruder	3A-2
	Folding machine	
	Graduating "	
	Hammer - Air	
	Mechanical	
	Steam	

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Metal Forming Equipment (contd)	Knurling machine	
	Marking "	
	Punching "	
	Riveting "	
	Rolling "	
	Rotary table	
	Shearing machine	1A-3
	Straightening machine rolls	2A-2
	Surface plate	3A-2
	Wire braiding machine	
	Wire bunching "	
	Wire cabling "	
	Wire stranding "	
Metalizing equipment	Electron beam	1B-2
		2B-2
	Flame	1B-2
	Plasma spray	1B-2
		2B-2
	Solder spray	1A-1
	Spray gun	1A-2
	Vacuum chamber	1D-2
		2D-3
Meters		1B-2
Mills		2A-2
		3A-2
Mixers	Barrel	
	Conical	1D-2
	Continuous	2D-3

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Mixers (contd)	Double arm	1D-2 2D-3
	Drum	
	Dual level	
	Extruding, screw type	2A-2
	High shear	1D-2 2D-3
	Homogenizing	2D-3
	Impeller	1D-2 2D-3
	Kneading	
	Muller	2A-2
	Paddle	1D-2 2D-3
	Pipeline	
	Portable	
	Propeller	
	Ribbon	2A-2
	Roller	1D-2 2D-3
	Rotary blades	
	Rotating pan	
	Screw	
	Spiral	
	Tumbler	
	Ultrasonic	
	Vibratory	
Motors	AC motors	1B-4 2B-4
	DC motors	
	Induction motors	
	Polyphase "	
	Single phase	
	Universal motors	
	Variable speed	

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Molding Machine	Injection	2A-2 3A-2
	Jolt	
	Rock over	
	Rollover	
	Sand slinger	1A-3 2A-2
	Shell	
	Squeeze	
	Turnover	

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Numerical Control Units	for Machine Tools	1B-2 2B-2

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Ovens	Bell type	
	Cabinet type	
	Combination car & drawer type	
	Continuous conveyor type	
	Continuous pusher type	
	Continuous roller hearth type	
	Continuous rotary hearth type	
	Continuous tower type	2F-1
	Dielectric	2F-2
	Drawer type	3F-1
	Glass annealing	3F-2
	Glass tempering	
	Multi-compartment	
	Pit type	
	Portable	
	Shelf ovens	
	Walk-in type	

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Packaging Equipment		2E-3 3E-3
Paint Spray Booths		2C-2 3C-2
Partitions		2C-1 3C-1
Pelletizer		2A-1
Pipes		3B-3
Precision Equipment	Alignment systems 1A-1 1B-2
	Cameras	
	Microscopes	
Press	Bonding press 2A-2 3A-2
	Forming & shearing	
	Hydraulic	
	Manual	
	Mechanical	
	Pneumatic	
	Press brake	
	Punch press	
	Printing	2A-1 3A-1
	Tableting press	2A-2 3A-2
Pressure vessels	Air receivers	2D-2 3D-3
	Autoclaves	1D-1 2D-3
	Gas cylinders 1D-1
	Gas tanks	
	Percolators 2D-2 3D-3
	Reactor vessels	

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Pulp Beater		2A-2 3A-2
Pulping Machine		1A-2 2A-2
Pumps	Adjustable flow	
	Axial flow	
	Booster	
	Centrifugal	
	Cryogenic	
	Deep-well	
	Diaphragm	
	Double section	
	Gear	
	Hand	
	Helical	1A-2
	Impeller	2A-2
	Multi-stage	
	Piston	
	Reciprocating	
	Rotary	
	Rotor/stator	
	Screw	
	Slurry	
	Submersible	
	Turbine	
	Vacuum	

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Reactors		2D-3 3D-3
Recorders	see "Instrumentation"	1B-2
Rectifiers		1B-3
Refrigerators		1A-1 2A-1
Regulators		1B-2
Relays		1B-3
Roasters		2A-1 3A-1

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Sand Blasting Equipment	Cabinet type	
	Car type	1C-2
	Conveyor belt type	2C-2
	Roller type	3C-2
	Rotary table	
Scales	Batch scales	1A-1
	Conveyor scales	3A-2
	Counter scales	1A-1
	Floor platform scales	3A-2
	Lever & spring scales	1A-1
		3A-2
	Portable scales	1A-1
	Yard scales	3A-2
Scalpers	see "Separators"	2A-1
		3A-1
Screen	Air sifter	
	Centrifugal	
	Electric vibrating	
	Fluidizing	
	Grizzlies	1A-2
	Gyratory	2A-1
	Perforated plate	
	Rotary	
	Trommels	
Scrubbers	Acid mist	
	Conical	2D-3
	Cyclone	3D-3

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Scrubbers (contd)	Jet ejector 2D-3 3D-3
	Packed bed	
	Vent stack	
	Venturi	
Separators	Air classifying 2A-1 3A-1
	Centrifugal	
	Cyclone	
	Decanters	
	Electrostatic	
	Flotation	
	Fluidizing	
	Gyratory	
	Ion-exchange	
	Jiggs	
	Magnetic	
	Membrane	
	Packed bed	
	Scalpers	
	Shaking tables	
	Sieves	
	Sifters	
	Vacuum belt	
	Vibrating	
Shredder		1A-2
Sieves		2A-1 3A-1
Sifters		2A-1 3A-1

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Sintering Equipment		3F-1 3F-2 3F-3
Soldering Machine	Commutator type Dip (wave) Gas	2A-2
Stacks	Concrete Steel	3F-3 3G-2
Steam Generators		2F-2 3F-2
Switch Boards	see "Panels"	1B-2 2B-2 3B-2

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Tanks	Brick-lined	
	Fiberglas-lined	
	Flotation	
	Gas tank	
	Glass-lined	
	Plastic-lined	1C-1
	Rubber-lined	2C-2
	Settling tank	3C-3
	Spherical	
	Stainless steel clad	
	Storage tanks	
	Waste tank	
	Water tank	
Textile Machinery	Looms	
	Knitting machines	1A-2
	Sewing "	2A-1
	Spinning "	3A-1
	Texturing "	
Towers	Absorption	2D-3
		3D-3
	Cooling	2C-3
		3C-4
	Cracking	
	Distillation	2D-3
	Drying	3D-3
	Fractionating	
	High-voltage	3G-1
	Quenching	2D-3
	Recovery	3D-3
	Stripping tower	3D-3
	Water towers	2C-3
		3C-4

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MAIN DIVISION	SUBDIVISION	CATEGORY
Transformers		1B-3 2B-3 3B-4
Transmission Lines		3B-3
Transmitters		1B-2
Tubingsee "Pipes"	3B-3
Turbines	Gas] Steam]	2A-2 3A-2

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Valves	Air release	
	Angle	
	Back pressure	
	Ball	
	Blow-off	
	Butterfly	
	Check	
	Control	
	Diaphragm	
	Disc	
	Drain 1A-2
	Float	
	Globe	
	High pressure	
	Needle	
	Pinch	
	Regulating	
	Relief	
	Safety	
	Solenoid	
	Vacuum	
Vehicles	Bulldozer	
	Buses	
	Dump trucks	
	Excavator 2E-1
	Forklifts 3E-1
	Low loaders	
	Mower	
	Passenger cars	

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Vehicles (contd)	Plows & harrows	
	Railroad freight cars	
	Roller	
	Scraper	2E-1
	Tractors	3E-1
	Trailers	
	Wagons	

EQUIPMENT INDEX

MAIN DIVISION	SUBDIVISION	CATEGORY
Washers	Drum washer	
	Sluice washer	2A-1
	Tank washer	3A-1
Water Blast Cleaning Equipment		1A-2
Wax Injection Press		1A-2
Welding Equipment	Arc welder	
	Butt welder	
	Electric resistance welder	
	Electron beam	1B-2
	Gas	2B-2
	Plasma	
	Spot	
Welding Screens		2C-1
		3C-1
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MAIN DIVISION	SUBDIVISION	CATEGORY
X-Ray Machine		IA-2

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**CRISIS RELOCATION
INDUSTRIAL HARDENING PLAN**

**HARDENING
ACTIVITIES**

BOOKLET 9

SCIENTIFIC SERVICE, INC.

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 9

HARDENING ALTERNATIVES

This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

Booklet 9

HARDENING ALTERNATIVES

Hardening Operations Manager: _____
(name)

Alternate: _____
(name)

Objective: To identify specific hardening methods appropriate to your plant.

GENERAL APPROACH AND GUIDELINES

Hardening Alternatives: Basic approaches to hardening solutions.

Hardening choices occur initially with the decision to either harden the equipment, harden replacement equipment, harden materials or alternative process equipment, or evacuate the equipment to a low-risk area. Alternative decisions occur again when equipment is located inside, on, or adjacent to buildings or other structures that can damage the equipment when they fail. The alternatives for these cases are to move the equipment outdoors, harden the equipment in place, harden the building, or remove the building.

Methods of hardening should be determined for as many alternative approaches as possible so that the most expedient and effective method can be found. List each possible approach, estimate the manpower and other resources required and the new survival rating of the equipment. Compare the time, effort, and improved outcome of the various proposed methods and choose the most effective and expedient approach.

Use combinations of several approaches where possible -- for example, removal of the building siding, guy bracing the structural frame, and shielding equipment in place after packing and burying the attached control components.

DESCRIPTION OF HARDENING ALTERNATIVES

Evacuate Equipment:

Remove equipment to a low-risk area. Usually applicable to small and medium size equipment that is easily transported. Weather protection must be considered. (See Figure 1)

Relocate and Harden Equipment Onsite:

Remove equipment to a safer location onsite where hardening is simpler. (See Figures 2, 3, and 4)

Harden Equipment in Place:

Strengthen or protect the equipment in place to increase its blast resistance. (See Figures 5 and 6)

Harden Replacement Materials and Equipment:

Protect materials and equipment that can be used to replace existing equipment.

Substitute-Process Hardening:

Identify a simpler, substitute process that can be used in place of the present one, and harden the materials, tools, etc., needed to put the alternative process in operation.

Example: Canning foods in recycled cans --

- (1) Use a hand-operated lid roll forming tool to install the lids on the cans;
- (2) Use wax to seal the cans for local distribution.

GENERAL HARDENING ALTERNATIVES FOR EQUIPMENT IN BUILDINGS

Most equipment is inside, adjacent to, or on buildings or other structures where failure of the building or structure would cause heavy damage to the equipment.

Move Equipment:

Move equipment away from the source of the damage; i.e., heavy building elements. In heavy concrete buildings this will require that the equipment be moved outdoors, clear of the building, and provided with weather protection. In buildings with very lightweight roofs (wood, sheet metal) and heavy reinforced concrete walls, the equipment can be moved to a central location (if it is clear of where walls would fall) to provide protection. When clear of collapsing heavy sections, and anchored to prevent overturning or sliding into other items, equipment will equal its highest blast survival rating in the catalog of Booklet 8. (Figure 7)

Harden Equipment:

Strengthen and/or protect equipment from the collapse of the building or structure. This approach is most effective for equipment that is relatively blast resistant (heavy machinery, steel, heavy-walled pressure vessels) and inside lightweight buildings (wood, sheet metal, asbestos, etc., roofs and siding, etc.). (Figure 8, also 5 and 6)

Remove Building:

Remove the source of the initial equipment damage -- missiles created during building wall failures and collapse of the building frame. Some types of structures can be collapsed quickly in controlled directions to avoid equipment. Disassembling the building has the advantage of possibly saving the materials needed for reconstruction. Building members laid flat on the ground have a much greater survival rating (provided they are held down). Removal of concrete block or brick walls eliminates a serious source of missile damage. (Figure 9)

Harden Building:

Strengthen steel frames of buildings where siding has been removed by guying, bracing, and reinforcing members and joints. This alternative can be used effectively to increase the survival rating of equipment otherwise damaged by failing beams, trusses, and columns (Figure 9). Guy bracing and reinforcing is also an effective method of protecting overhead bridge cranes. For heavy concrete buildings, below-ground basements can be shored to provide equipment protection (Figure 2).

SPECIFIC RISK-AREA EQUIPMENT HARDENING METHODS

Securing Equipment:

Bolt and/or weld equipment to solid foundations, or secure equipment in large, stable clumps (see Figure 4 for a simple example) to prevent collision-impact damage from sliding or overturning. Equipment should have a strong base and support frames (and good equipment component attachments to that frame). Provide ductile steel bolt-down angles or brackets where possible to reinforce equipment mounts made of cast steel. For equipment with vertical height greater than the smaller dimension at its base, securing should be combined with guying or bracing, if equipment cannot be placed on its side.

Above or Below Grade Burial:

Equipment can be protected with crushable cushioning materials, covered with a dust barrier (plastic sheet, canvas, blankets, etc.) and then buried under several feet of soil. This effective, proven method for protecting equipment has been tested during weapons test experiments. (Figure 10, 11, and 12)

Protective Shelter:

A framed structure built around and over the equipment to protect equipment from building collapse damage. (Figure 6)

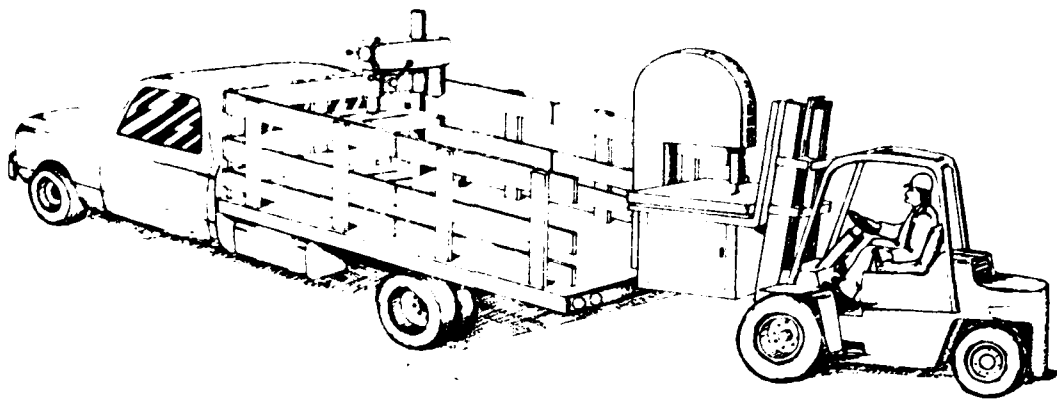
Screen Shelter:

A sandbag or dirt berm, or braced and guyed fence-type structure constructed around the equipment to protect the equipment from missiles and high-velocity winds. (Figure 7)

Guying, Bracing, and Anchoring:

Guying with wire rope or bracing with steel members the upper parts of equipment and structures. Primarily used on immovable, tall equipment with medium to heavy steel frames (Figure 9). Anchors used with guys and bracing, or with stable arrays of equipment packages to prevent sliding (Figure 13).

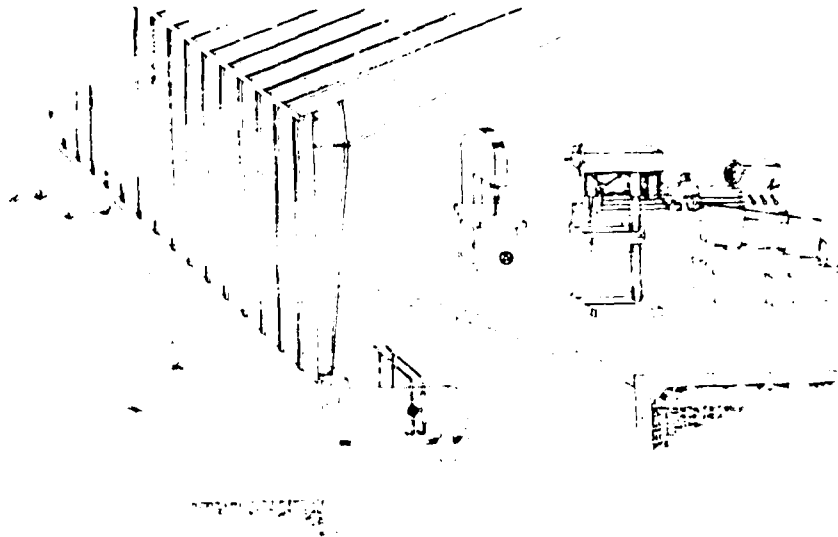
EVACUATE



LOAD EQUIPMENT AND MOVE IT AWAY
If You Can Take All Of It - Do So!
If You Can Take Only Part Of It,
Select the Irreplaceable Items - Key
Maintenance And Repair Manuals And
Tools, And Recovery Equipment - To
Evacuate.

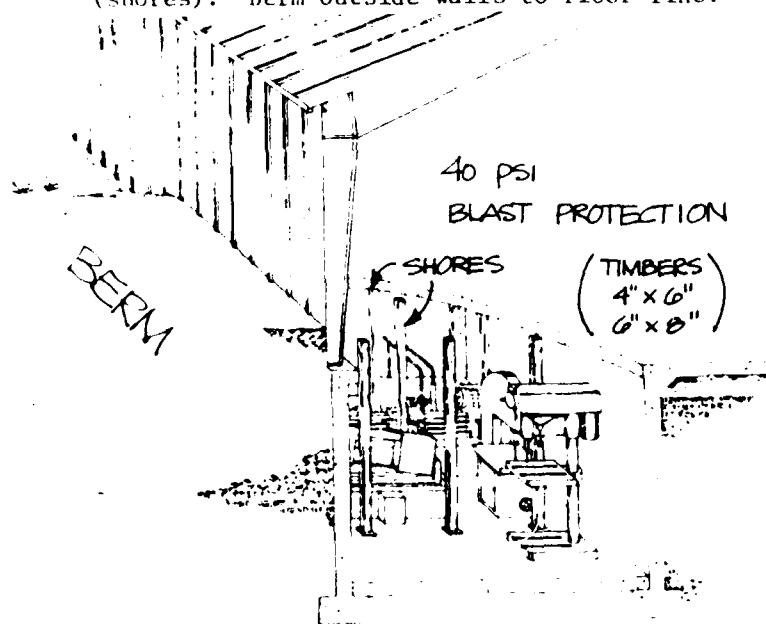
Fig. 1.

MOVE EQUIPMENT TO A SAFER PLACE IN THE PLANT STRUCTURE AND HARDEN STRUCTURE...



TO HARDEN STRUCTURE
(It Must Have a Basement!)

Reinforce basement space with supporting timbers (shores). Berm outside walls to floor line.



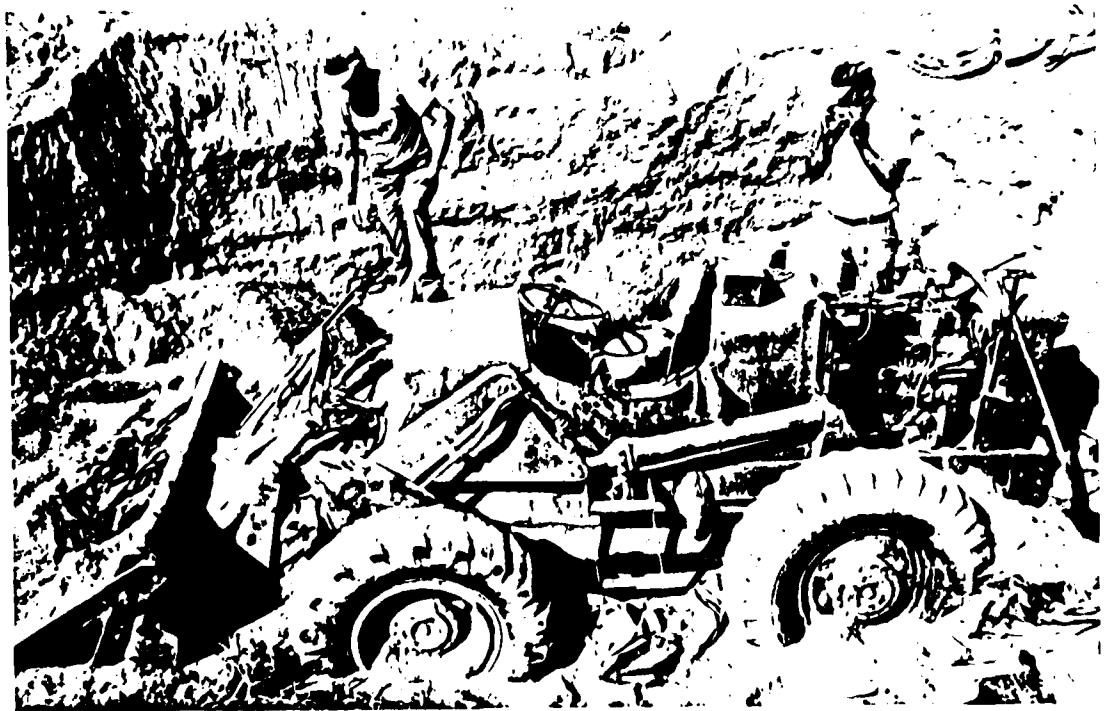
RELOCATE EQUIPMENT UNDERGROUND IN SHORED BASEMENT

Fig. 2.

IF YOU CAN MOVE THE EQUIPMENT BUT CAN'T HAUL IT AWAY ...



BURY IT OUTDOORS
In Paved Areas - Sandbag It
Blast Protection: 50 psi



IN OPEN AREAS - PUT IT IN A TRENCH
(COVER IT IF THERE'S TIME)
Blast Protection: 20 psi (Open Trench)
300 psi (Covered Trench With Crushable Layer)

Fig. 3.

Where open space is plentiful and equipment is movable, but you cannot cover it (because cover or covering equipment is lacking) - weld equipment together in clusters that have a ratio of H/B less than $\frac{1}{2}$, and place them 2B apart.

Drums (e.g., of hazardous materials) are particularly suitable for this type of hardening (provided they are full and closed). Truckers or climbers webbing (7,000 lb strength) can be used to strap them together.

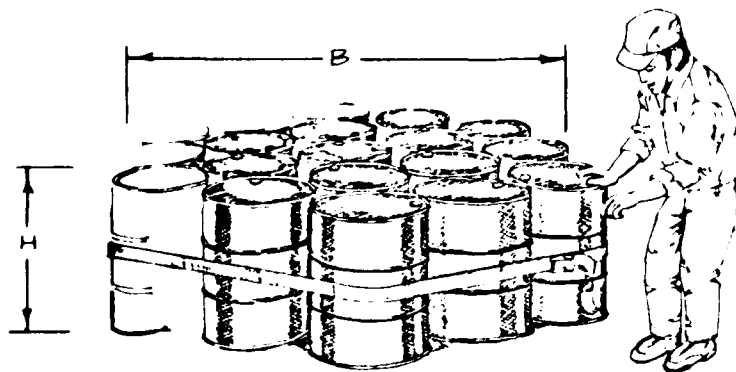
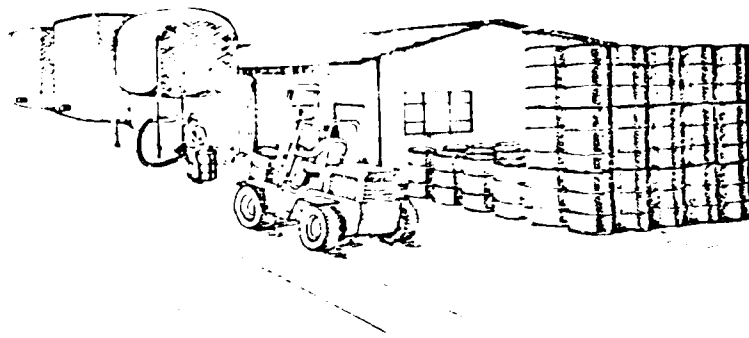
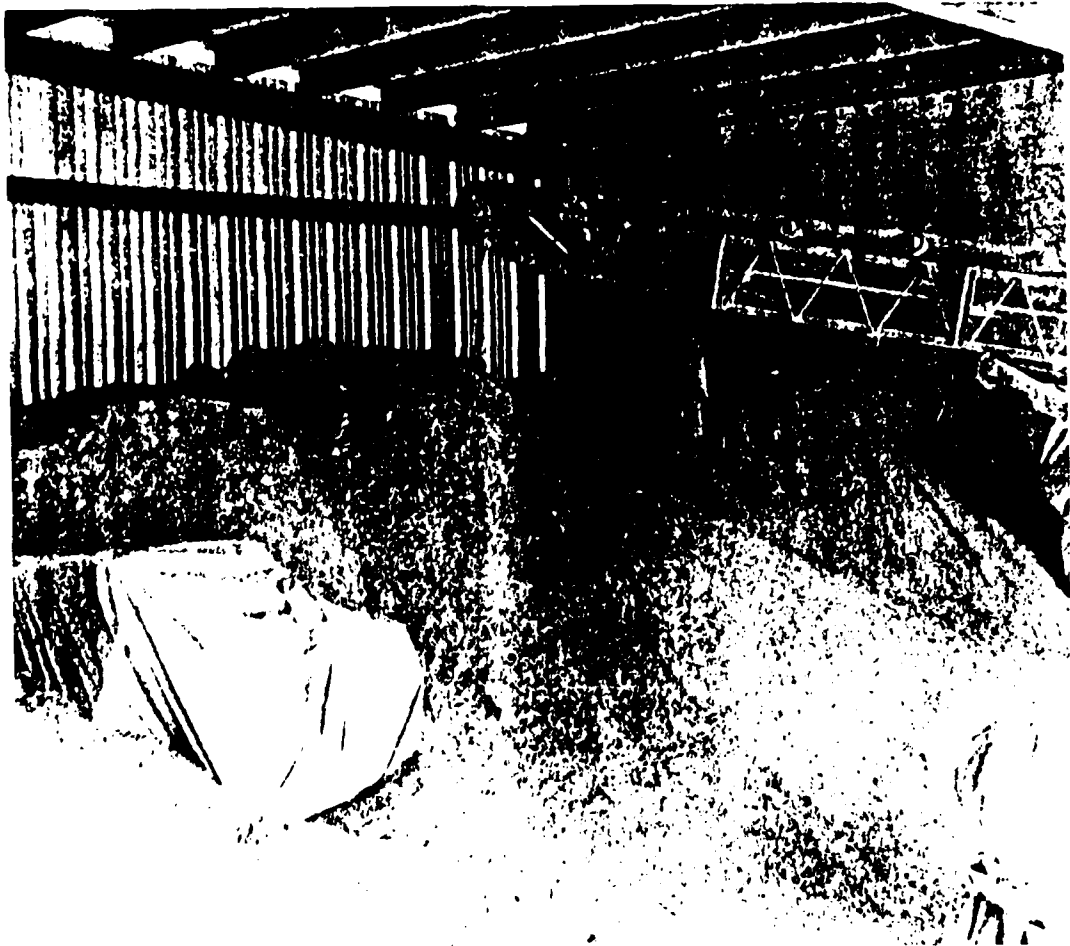


Fig. 4.

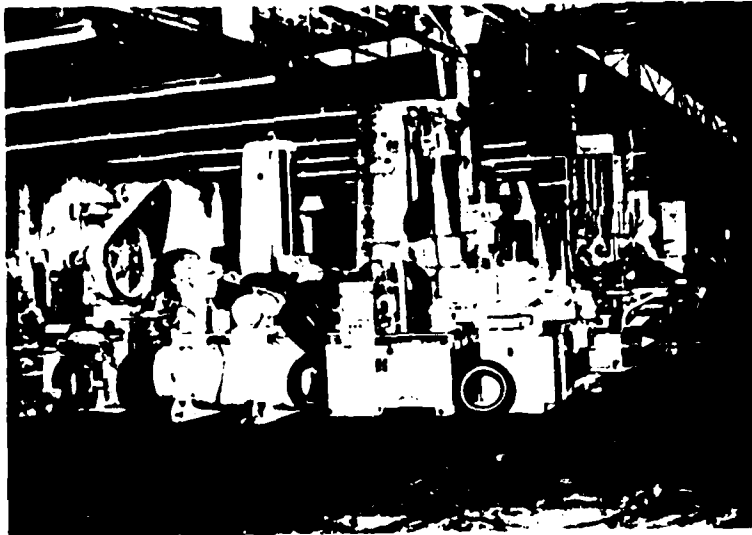
BURY IT INDOORS



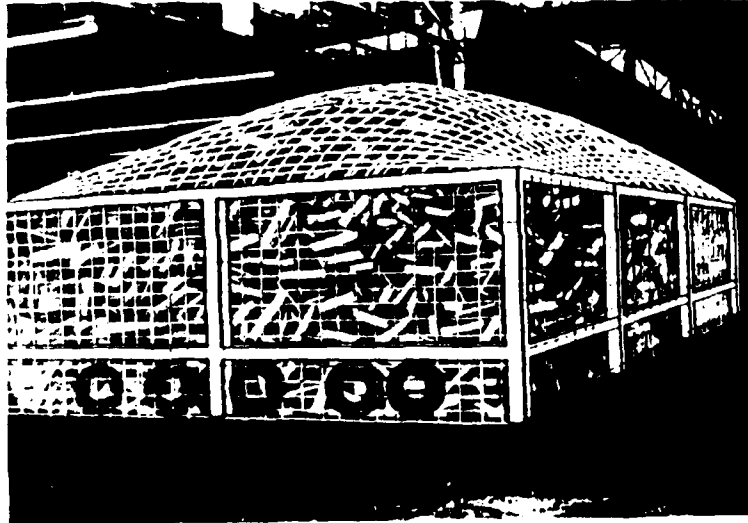
Blast Protection: 300 psi

Fig. 5.

IF YOU CAN'T BURY OR MOVE IT ...



Cluster Movable Equipment Around It; Wedge Wood Or Tire Bumpers Between Equipment To Protect Knobs, Handles, Etc.



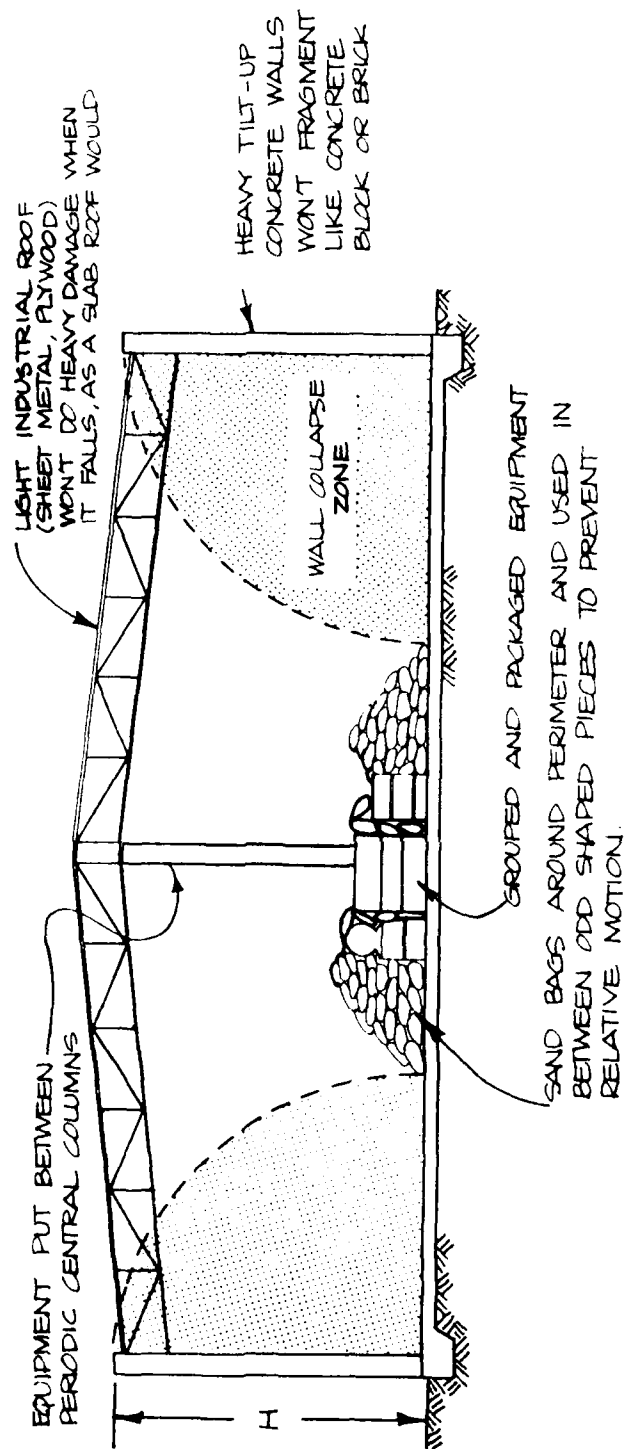
Weld Heavy I-Beam Crib Around it; Add Chain Link Fence; Stuff With Tires or Lumber; and Cover.

Blast Protection: 20 to 30 psi

Fig. 6.

CONDITIONS: Little Outdoor Space, Neighboring Buildings 2 Ft Apart Or Less

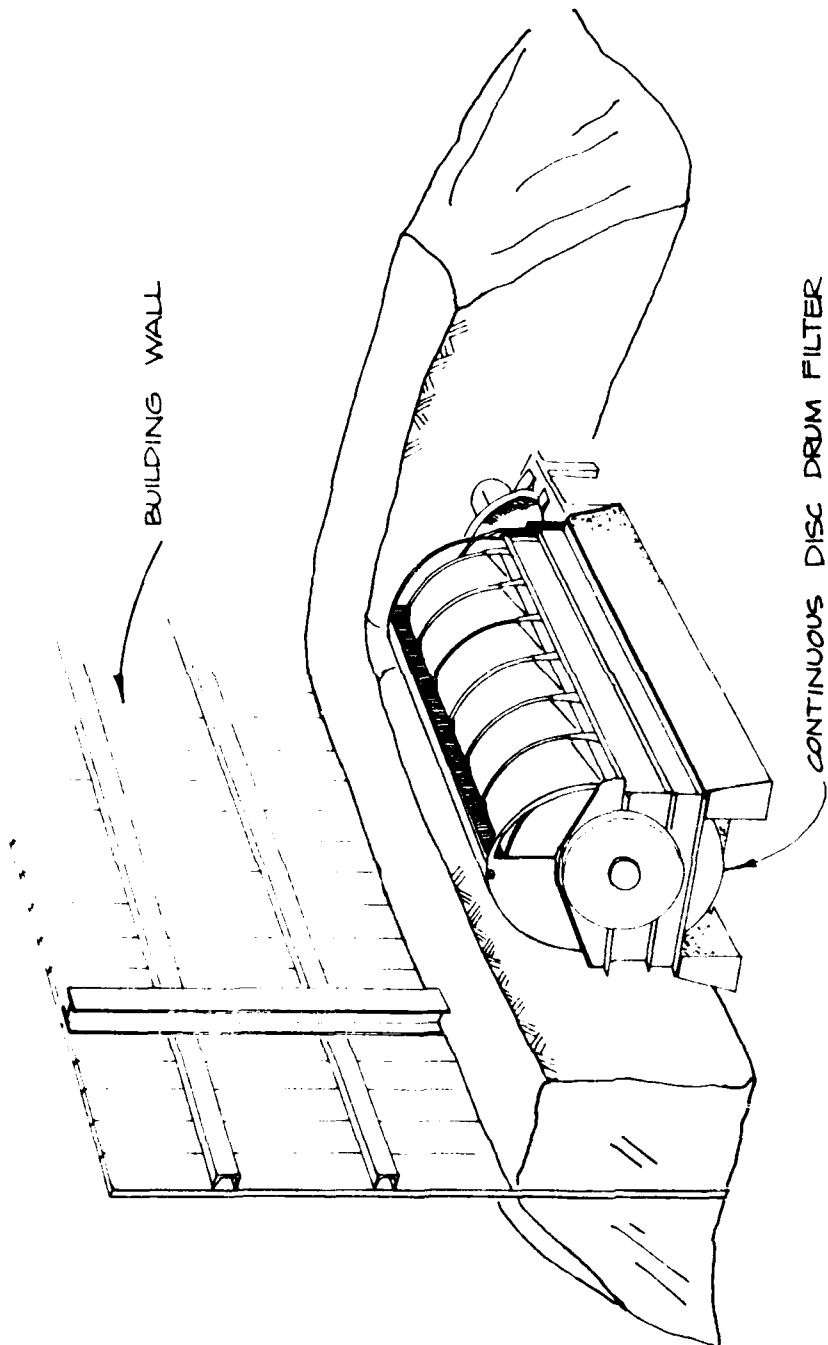
- o Fragile equipment evacuated.
- o Sand bags and grouping of equipment provides protection from missiles, light roof collapse, and high winds. (Light weight equipment cushion packed and crated.)
- o Equipment moved from heavy-wall collapse zone.



SCREENING

Blast Protection: 5 psi (Light Frame Equipment And Closed Panel Construction)
25 psi (Heavy Frame Equipment And Open Panel Construction)

Fig. 7.

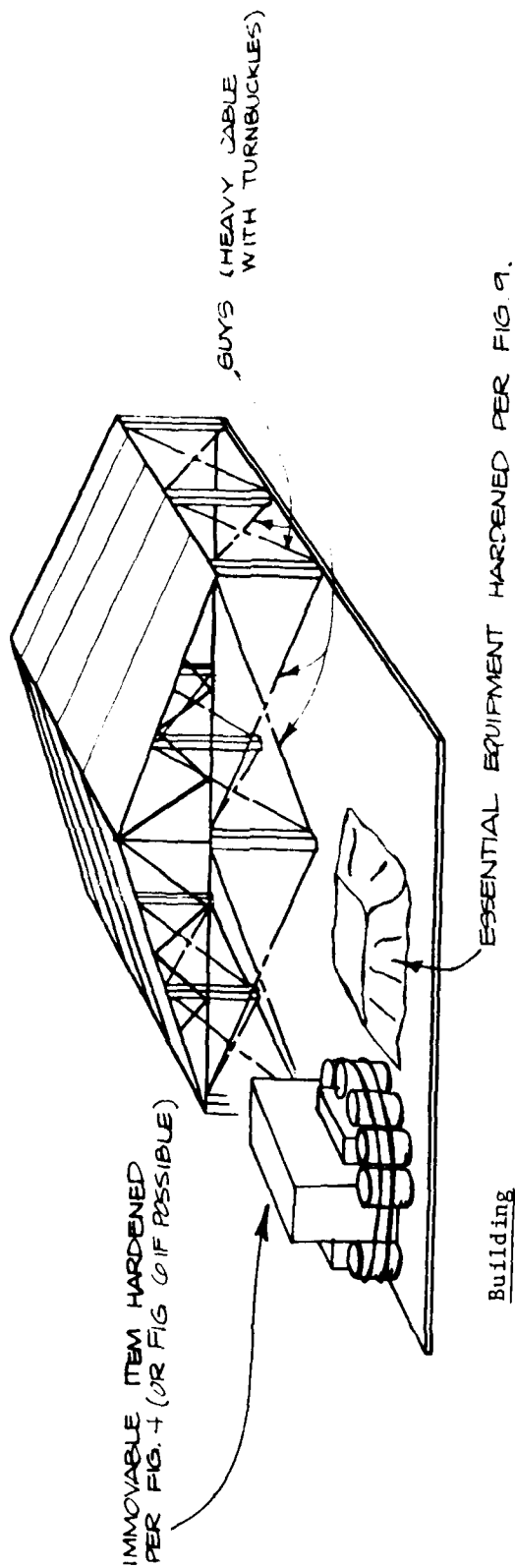


WITH 4" CRUSHABLE MATERIAL ON TOP AND 2' OF SOIL

IN-PLACE BURIAL INSIDE BUILDING

Blast Protection: 300 psi (Loose Soil Cover)

Fig. 8.



Building

10 - 12 psi Blast Rating

- o Added Columns
- o Guy Braced Frame

Equipment

- o Above Ground Burial of Essential Equipment.
- o Cluster of Equipment and Water Filled Barrels Around Immovable Item of Equipment.

Fig. 9.

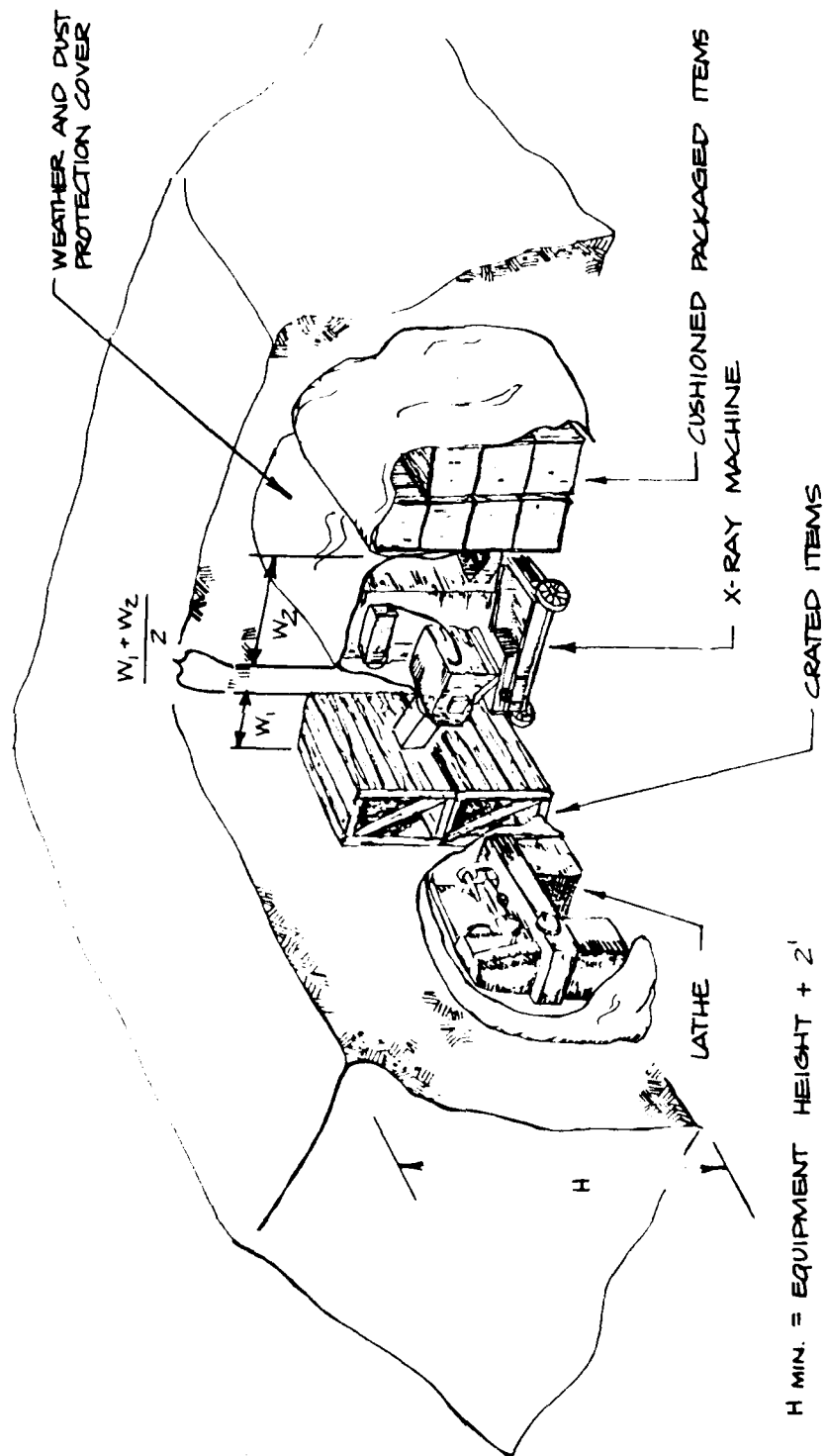
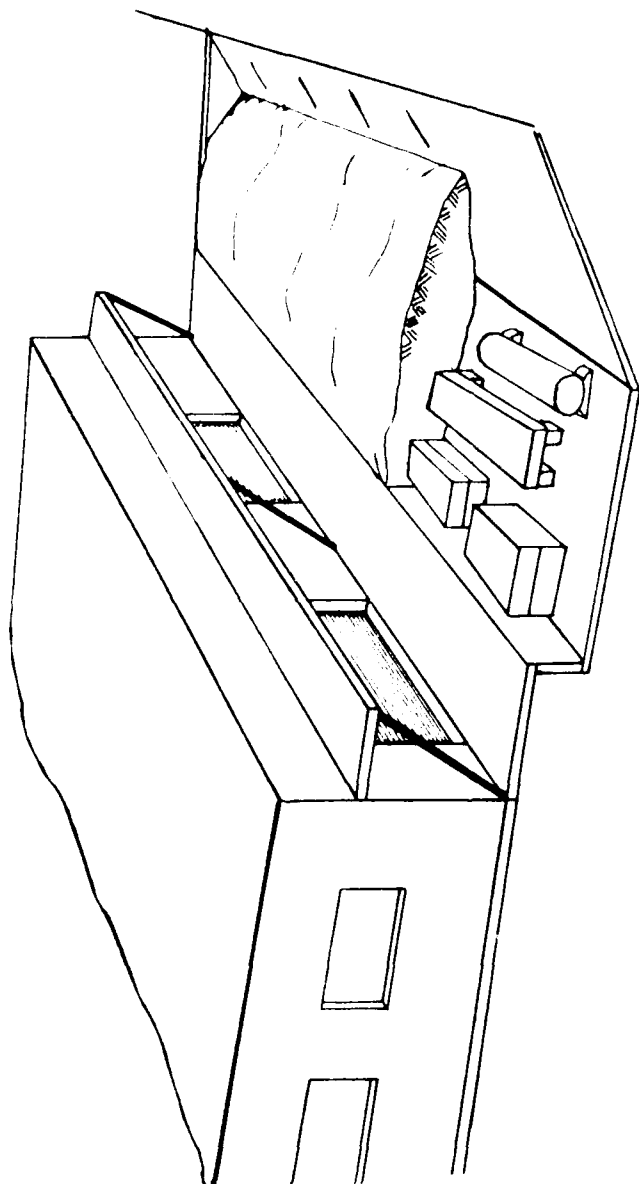


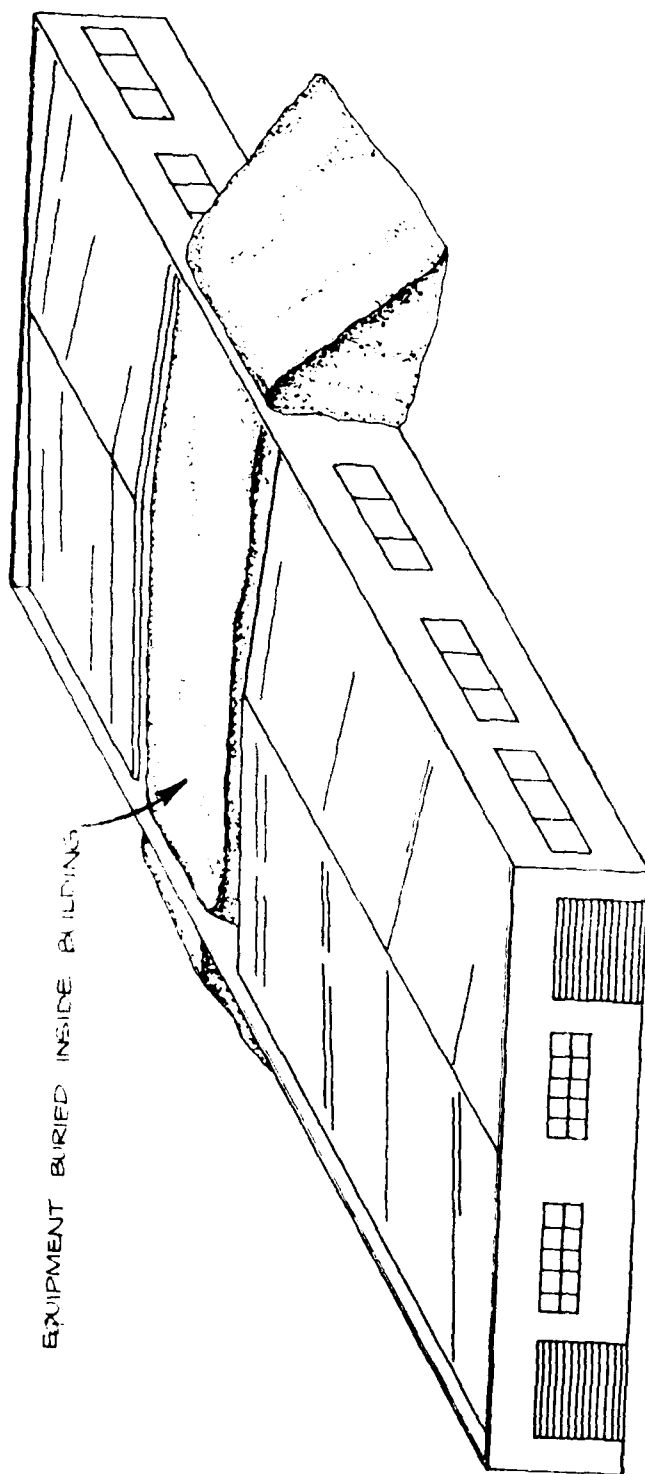
Fig. 10.



4" Crushable Material on Top of Each Buried Unit and 2' of Soil Spacing between
as in Fig. 10.

BURIAL IN LOADING DOCK AREA
Blast Protection: 300 psi (Loose Soil Cover)

Fig. 11.

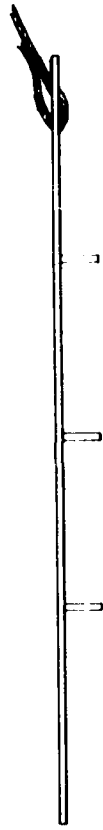


EQUIPMENT BURIED INSIDE BUILDING

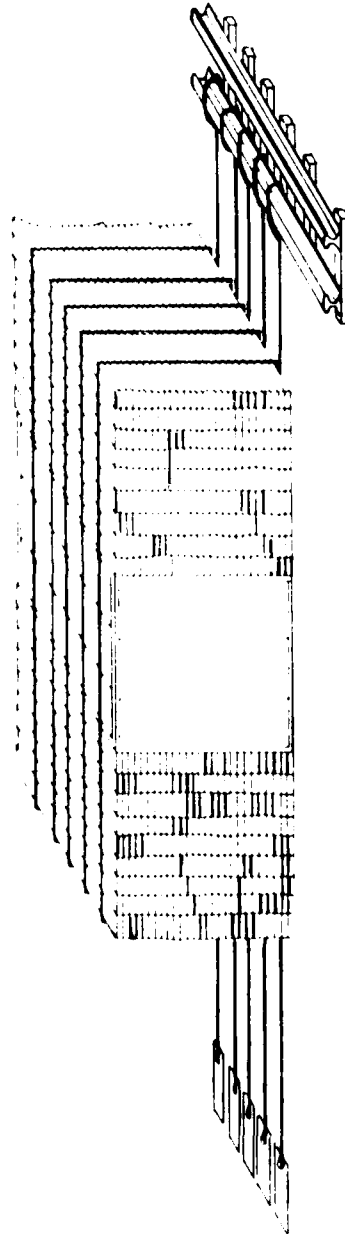
ABOVE GROUND BURIAL

Blast Protection: 50 - 300 psi

Fig. 12.



A. Expedient Anchor.



B. Tiedown Alternative

Fig. 13.

INDUSTRIAL

PROTECTION

GUIDE

**CRISIS RELOCATION
INDUSTRIAL HAPPENING PLAN**

CRISIS RELOCATION INDUSTRIAL HARDENING PLAN

Booklet 10

KEY WORKER SHELTER

This is one of ten booklets of the Industrial Hardening Manual
developed for the
Federal Emergency Management Agency
under Contract No. EMW-C-0154, Work Unit 1124E

SCIENTIFIC SERVICE, Inc.
Redwood City, California 94063

Note: Advance planning for industrial hardening is essential and many activities, including designing and implementing "Key Worker Shelters", can and should be accomplished well in advance of need. However, since there may be circumstances when there will be little advance warning, this booklet has been developed to enable you to accomplish the task in a crisis period; i.e., a few days, provided you plan now.

Booklet 10

KEY WORKER SHELTER

Coordinator: _____
(name)

Alternate: _____
(name)

Objective: To develop plant site shelter space for key workers of the key industries that operate through the crisis.

This booklet is part of a survival plan in the event of a major disaster. It will be vital to keep some industry operations running during a disaster -- for example, communications and power facilities. It is expected that key worker volunteers will be able to conduct most of these operations during the days and commute to their host areas at night. But some operations will be round-the-clock. In either case, onsite "key worker" emergency shelters will be required at such plants. Such shelters might also be useful at other plants for teams doing late hardening (see Glossary, p. 61) and early recovery, but would take time from hardening activities to build. For those building key worker shelters this booklet outlines the procedures.

- Step 1 -- Determine the number of key workers to be sheltered
- Step 2 -- Examine shelter requirements
- Step 3 -- Survey existing below grade structures for upgrading
- Step 4 -- Survey expedient shelters for upgrading
- Step 5 -- Assess shelter closures and entry alternatives
- Step 6 -- Assess shelter stocking
- Step 7 -- Complete the key worker shelter implementation analysis

STEP 1: Determine Number of Key Workers

- A. Decide exactly what equipment is to continue operating.
- B. Determine the minimum crew required.
- C. Add two additional members, one to monitor the radio and give warning to take shelter, and one to provide backup in case of an injury.

STEP 2: Examine Shelter Requirements

- A. Determine type of shelter needed; i.e., short stay-time, austere shelter (if your plant is on the fringe of a designated risk area and there are no other risk areas between it and the host area, or if there is a major risk area key worker shelter -- with space -- that can be reached in 10 minutes); or long stay-time, fully equipped shelter.
- B. Determine potential shelter availability:
 - (1) Basement or underground space that can be upgraded;
 - (2) Expedient Shelters: Facilities not originally intended for shelter protection or human habitation, which can be adapted with structural upgrading, as necessary, to protect key personnel.
- C. Based on type of shelter, there are general and specific criteria applied to each.

General Criteria

- o Shelters must be structurally capable of withstanding 40 psi or more and have sufficient radiation protection to limit shelteree exposure to an acceptable level. Only underground shelters are suitable to withstand 40 psi. Adequate radiation protection may be achieved with approximately 3 feet of earth cover (at a density of 110 lb per cubic foot), which will provide a protection factor $P_f = 1000$.

- o Shelters should be located so that debris or collapsing buildings, whether adjacent to the shelter or in the neighborhood, would not prevent escape of sheltered personnel.
- o Below ground shelters, unless they are water-tight, should not be located in high ground-water areas, nor in areas subject to flooding from surface runoff, ruptured tanks, or broken pipelines.
- o Shelters should not be located near hazardous or flammable materials.
- o Two exits should be provided, located as far apart as possible. Debris may block an exit, and an alternative escape exit should be available.
- o A minimum of 10 square feet of floor space and a minimum of 65 cubic feet of air volume should be provided per person.
- o Rather than one large shelter to house all of the key workers in an emergency, two or more smaller shelters should be built. This would greatly improve everyone's chances for survival, as a buddy system could be implemented and one group could help the other, should a problem arise.
- o Existing basement areas that are potentially available for upgrading and existing underground upgradable facilities must be capable of being cleaned and made habitable in 72 hours. The extent of cleaning necessary will depend upon the facility selected.
- o Tools and equipment to aid in exiting the shelter: blocks and jacks to remove debris and roadblocks during evacuation and for rescue of people from other shelters, as necessary.

Fully Equipped Shelter Criteria

In addition to meeting the general criteria, a fully equipped shelter should contain the following:

- o Sufficient life support supplies adequate for a minimum two-week stay time. A detailed list is presented under the stocking and management section, Step 6.
- o Ventilation equipment adequate to supply at least 3 cubic feet per minute per person. (Larger air flows up to 40 cfm may be required in the hot, humid areas of the country.) Equipment should be operatable by hand.
- o Radiation monitoring equipment.
- o Communication equipment.
- o Sleeping facilities.
- o Firefighting equipment.
- o Emergency power system.

A sketch of a typical fully equipped shelter is shown in Figure 1.

A short-term, or austere, shelter should contain:

- o Escape vehicles, either in or near the shelter, protected to 40 psi.
- o Minimal life support supplies.

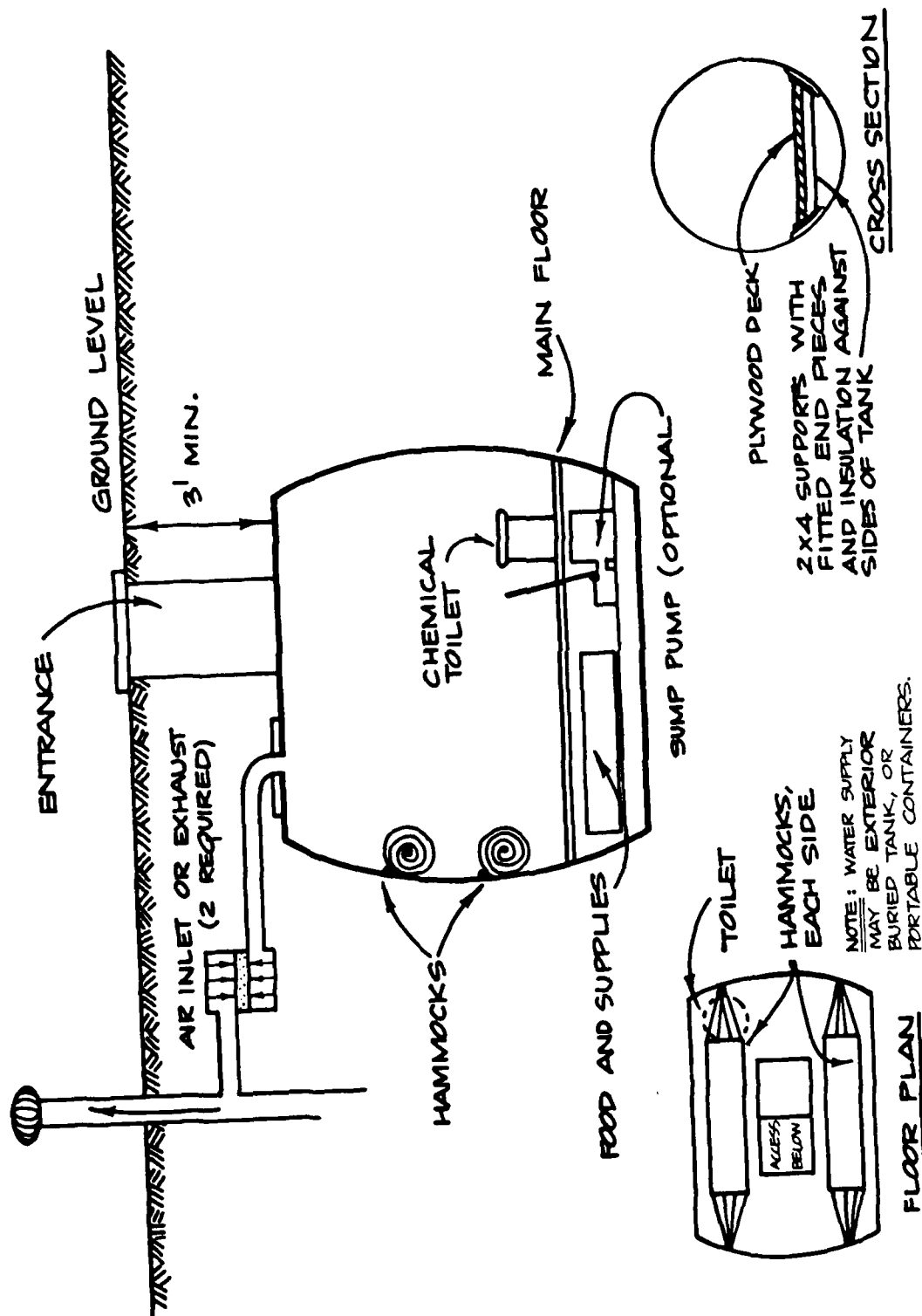


Fig. 1. Typical Equipped Shelter.

STEP 3: Survey Existing Structures for Upgrading

The most desirable and economical shelters in terms of resources and manpower are those that can be found in existing structures at or close to the work site, and these should be surveyed first. Choose two or more smaller shelters over one large one, if that option is available. This will enable one group to help the other, should a problem arise.

The criteria specify **underground structures**. Because of blast-induced soil pressures, only those basements with reinforced concrete walls are considered adequate. In most cases these will be found in structures that were built for heavy industrial use (designed for 150 to 250 psf) under building code requirements that prevailed at the time. If you have no underground structure or basement -- skip to Step 4 (page 22).

Candidate shelters will need to be upgraded. This generally will consist of reinforcing the floor slab above the basement (discussed immediately below) and providing blast-proof closures (discussed in Step 5). Shelters will also need to be equipped with the life support systems discussed in Step 6.

Upgrading of Floor Slabs.

Seven reinforced concrete construction types have been found to be upgradable. The upgrading techniques shown in the following pages are designed to upgrade the various construction types to withstand 40 psi blast loadings. The categories for the types of construction are according to type of floor slab:

Two-Way Slabs

Flat plate and flat slabs

Waffle slabs

Slab and girder

One-Way Slabs

One-way joist and one-way slab,
beam and girder

Double tee

Hollow-core

One-Way Slab and Girder

The upgrading techniques are of two types depending on the type of construction:

- o Post shores (compare page 9 with page 8)
- o Post and beam supports (compare page 15 with page 14)

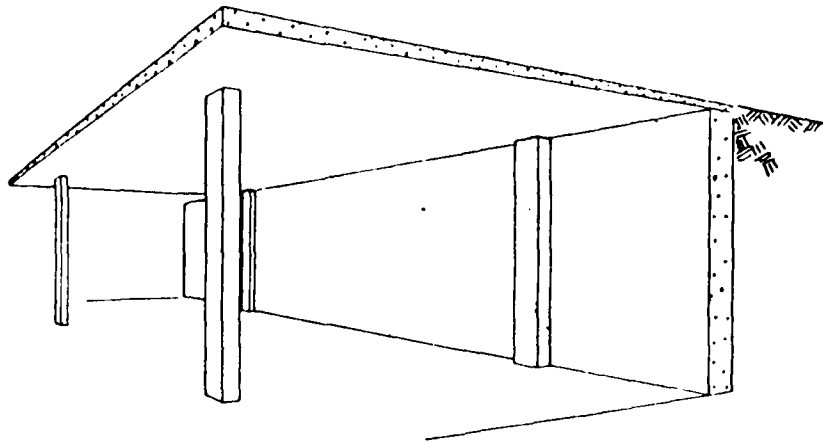
For either system, supports should be added at one-quarter of the span in both directions -- width and length. For example, if the span (distance between columns) is 20 feet, the supports are to be placed 5 feet on centers, and if the span is 40 feet, the supports are to be placed 10 feet on centers. The space between shores is greater for longer spans, thus fewer shores per shelteree are required. Long-span basement areas are expected to be few, however. A shelter requiring very close support shoring is best used only for short stay-time shelters.

The resources used in the upgrading procedures consist of:

- o Steel and wood posts
- o Steel beams

Wood beams cannot be used for upgrading to 40 psi because of stress limitations, which cause crushing of the beam fibers.

Upgrading details are shown in Appendix A.



Flat Plate and Flat Slab

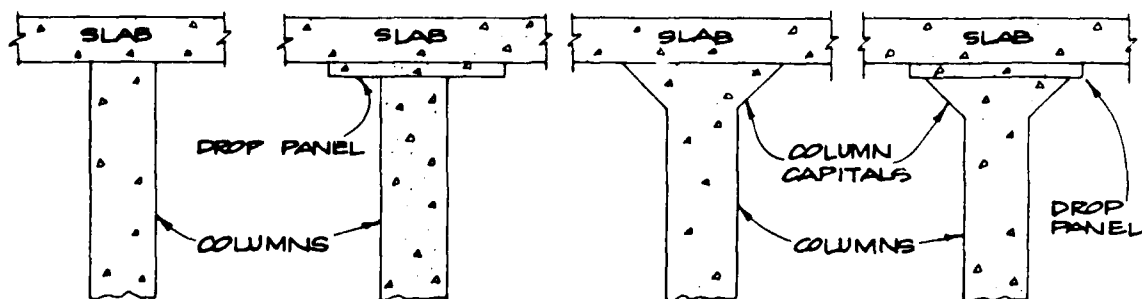
Characteristics and Construction Details

Concrete slabs are 8 inches to 12 inches thick without other detailed engineering or construction features.

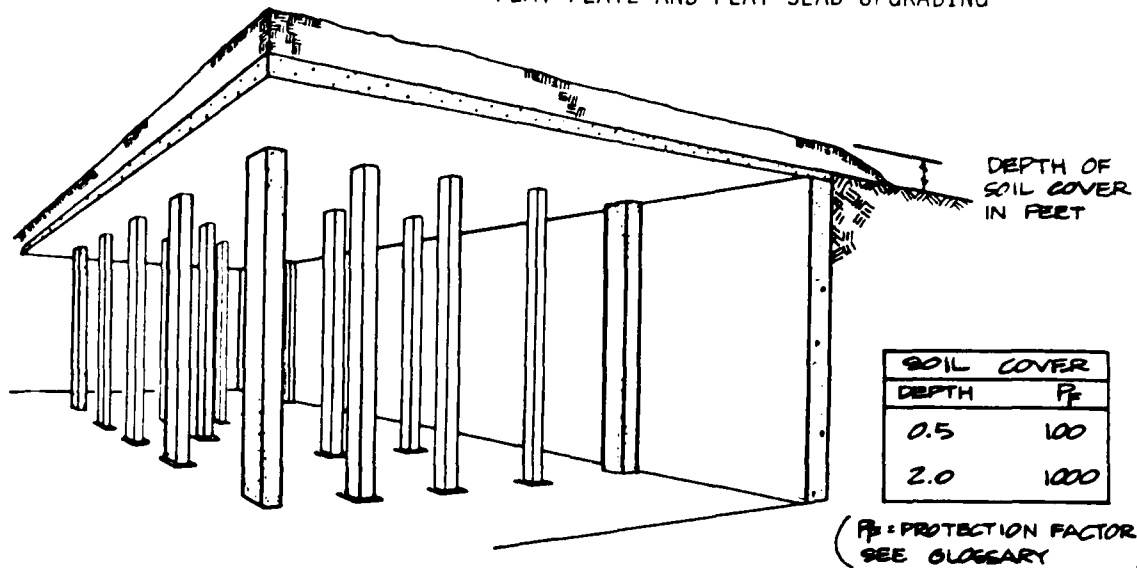
Columns are concrete and are constructed integrally with the floor slabs in a variety of ways as shown below. Columns may be round or square, and details refer to interior columns and columns constructed adjacent to a concrete wall.

Drop panels are usually 2 to 5 inches thick, and column capitals vary in height.

Spans between columns normally vary from 16 to 30 feet.

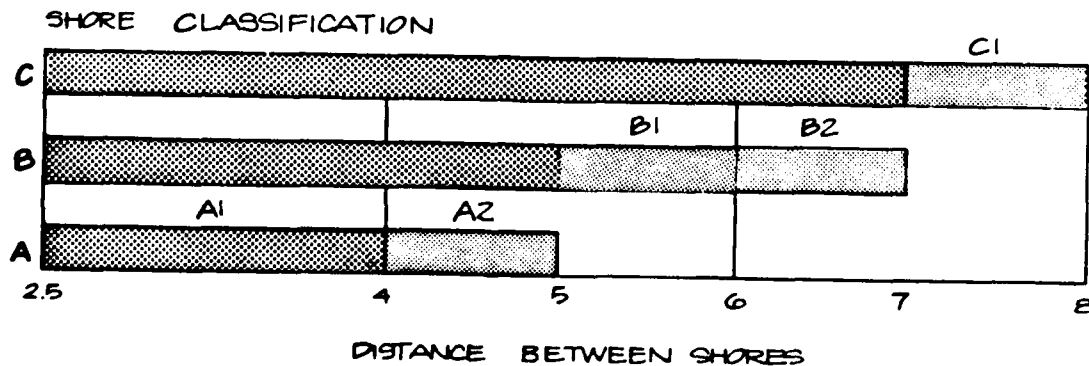


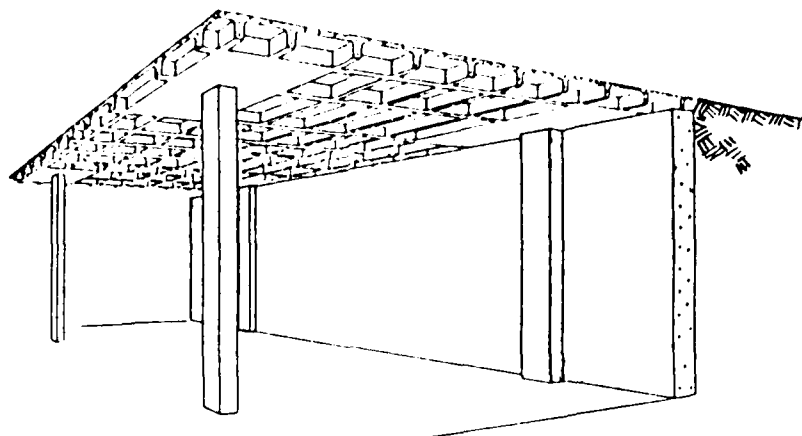
FLAT PLATE AND FLAT SLAB UPGRADING



Shoring

The recommended method for shoring flat plate and flat slabs is to use post shores, as shown in the sketch above. For shore classification see spacing chart below, and for types of shores refer to pages A-3 to A-5. Maximum unshored distance should not exceed 1/4 of the span.





Waffle Slab

Characteristics and Construction Details

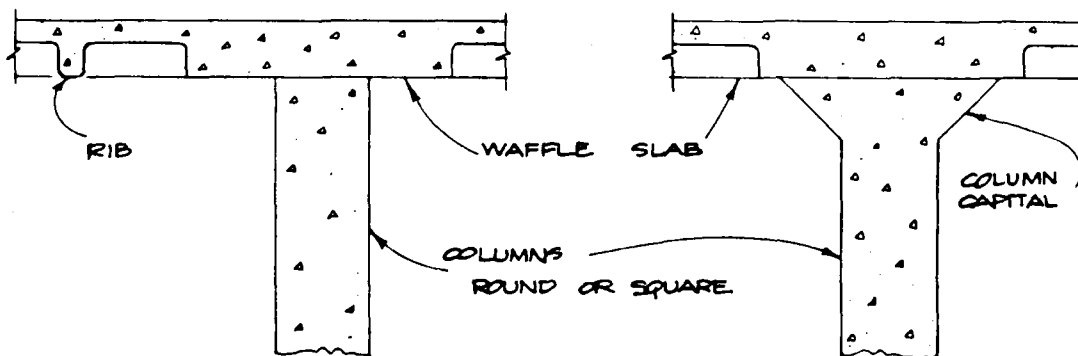
Concrete deck and ribs are cast as one unit. The industry standard waffle forms are 19 inches square and 30 inches square. Top slab thickness is usually 3 inches or 4½ inches.

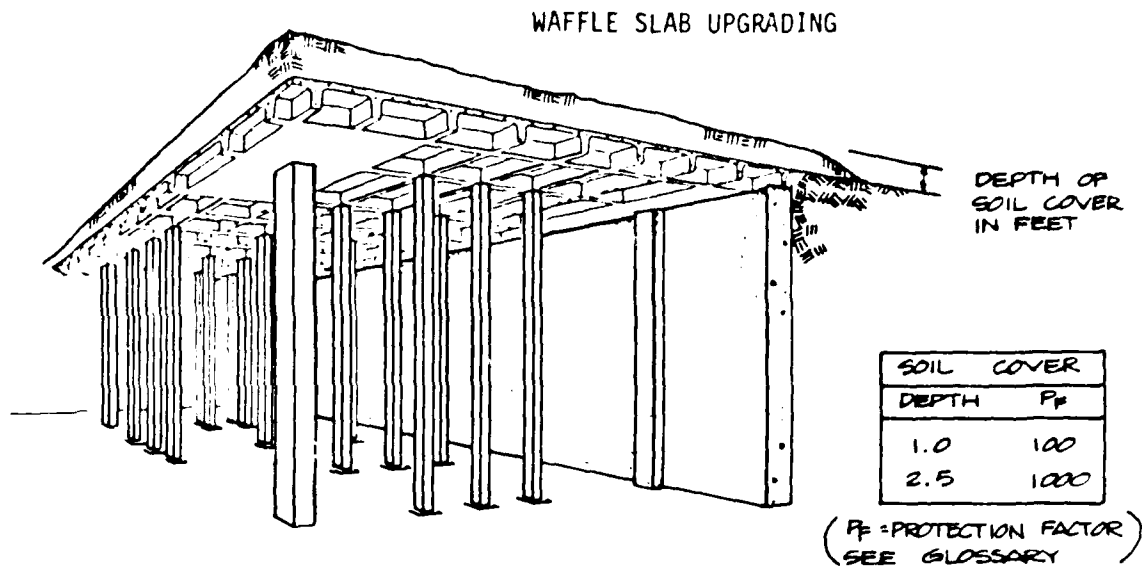
Ribs are 5 inches thick for 19-inch waffle forms, and vary in depth from 6 to 12 inches.

Ribs are 6 inches thick for 30-inch waffle forms, and vary in depth from 8 to 20 inches.

A non-waffled section is constructed around each column.

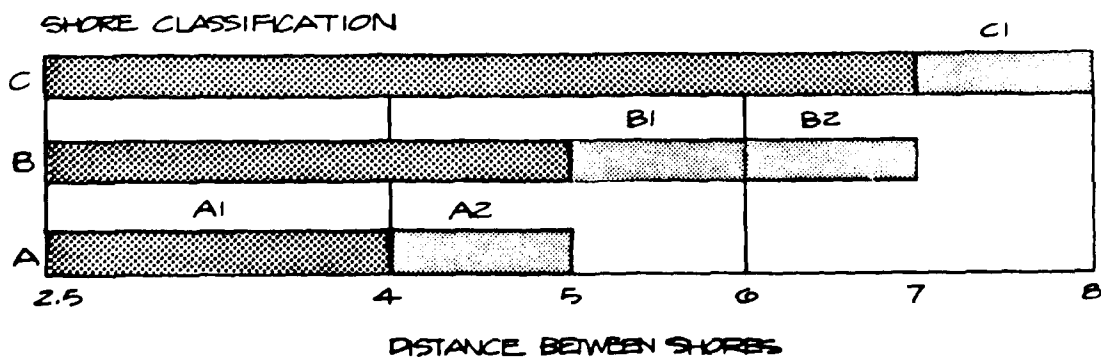
Columns are concrete and are constructed integrally with the waffle slab. Typical details are shown below. Spans between columns normally vary from 15 to 36 feet.

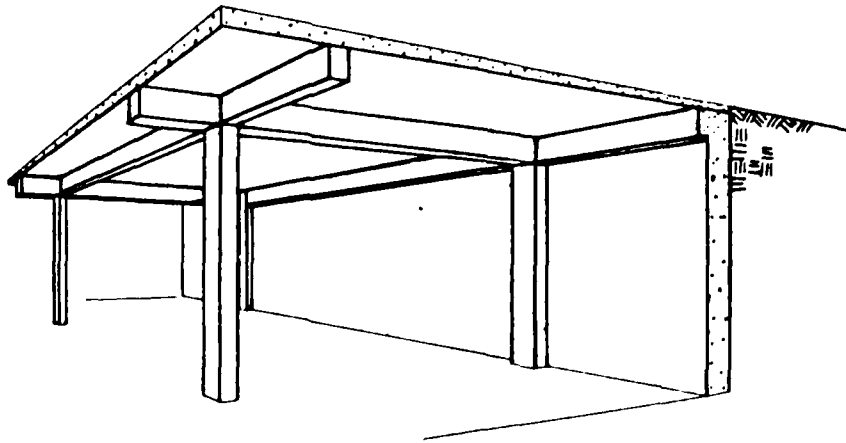




Shoring

The recommended method for shoring waffle slabs is to use post shores, as shown in the sketch above. For shore spacing, the posts must be placed at the intersection of the waffle ribs. Thus, for 19-inch waffles, the posts will be at multiples of 2 feet, and for 30-inch waffles, the posts will be at multiples of 3 feet. For shore classification see spacing chart below, and for types of shores, refer to pages A-3 to A-5. Maximum unshored distance should not exceed 1/4 of the span. More shores may be required for the waffle slab because of post shore location restrictions.





Two - Way Slab & Girder

Characteristics and Construction Details

Concrete slabs are 8 to 12 inches thick, and girders are cast with the slab.

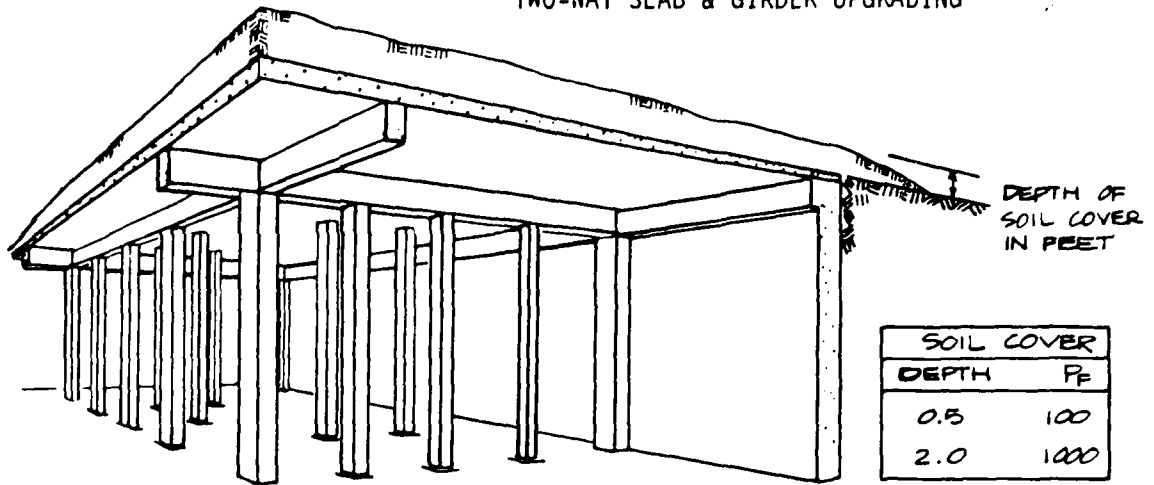
Columns are concrete, and are constructed integrally with the girders.

Columns are generally square or rectangular.

Girders are usually 12 inches wide or more and may be up to 36 inches deep in heavy, long-span structures.

Span between supports normally varies from 16 to 30 feet.

TWO-WAY SLAB & GIRDER UPGRADING



DEPTH OF
SOIL COVER
IN FEET

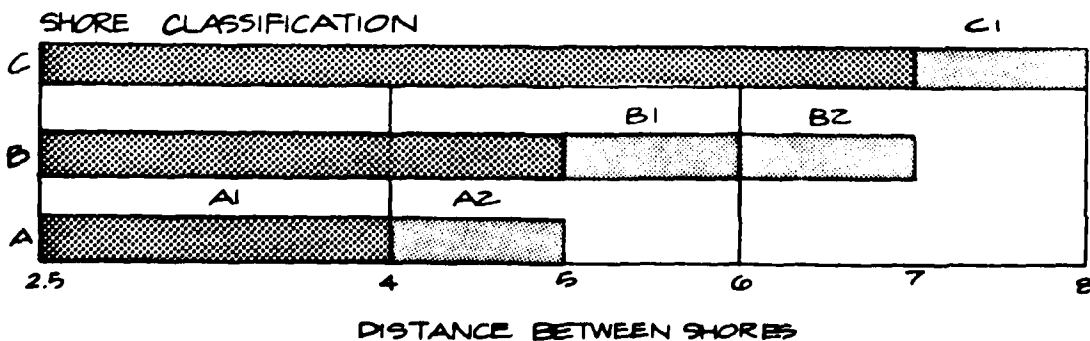
SOIL COVER	
DEPTH	P _F
0.5	100
2.0	1000

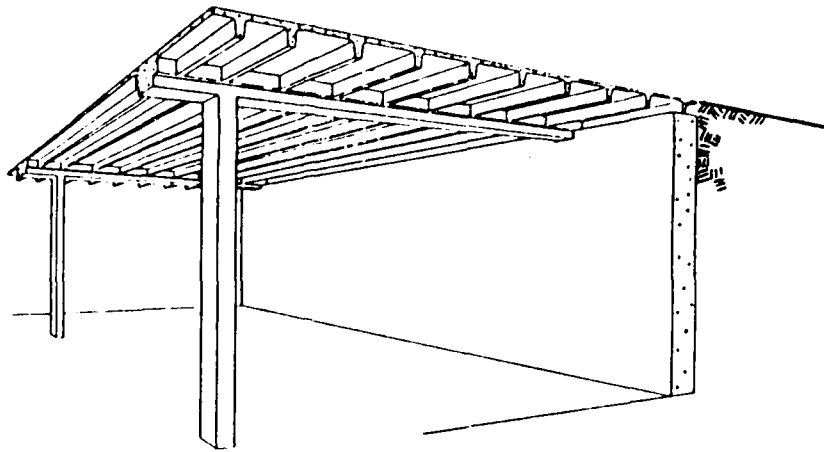
(P_F = PROTECTION FACTOR)
SEE GLOSSARY

Shoring

The recommended method for shoring two-way slab and girder is to use post shores, as shown in the sketch above. Two lengths of shores must be provided (for shoring the beams and the slab, respectively).

For shore classification see spacing chart below, and for types of shores, refer to pages A-3 to A-5. Maximum unshored distance should not exceed 1/4 of the span.





One-Way Joist & One-Way Slab, Beam & Girder

Characteristics and Construction Details

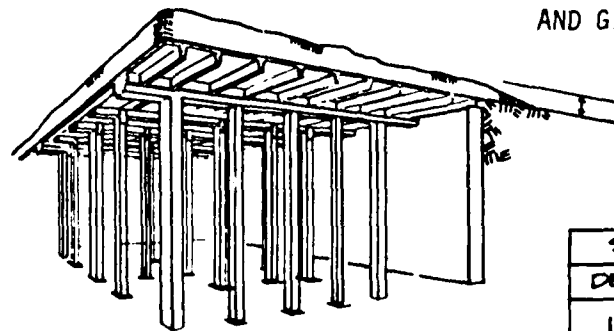
Concrete slabs are poured monolithically with joist ribs or beams, and girders.

Slabs for one-way joists are $3\frac{1}{2}$ to 4 inches thick. Joist ribs vary from 5 to 7 inches thick, from 10 to 20 inches deep, and are tapered. Spacings between ribs are usually 20 inches or 30 inches. Span length varies from 16 to 26 feet.

Slabs used in slab, beam and girder construction are generally 6 inches and thicker. Beams are generally not less than 10 inches wide, and girders not less than 12 inches wide. Depth of beams and girders vary and generally are not greater than 30 inches. Spans vary from 20 to 36 feet.

Columns are generally rigidly tied to girders and can be rectangular or square.

ONE-WAY JOIST & ONE-WAY SLAB, BEAM AND GIRDER UPGRADING



DEPTH OF
SOIL COVER
IN FEET

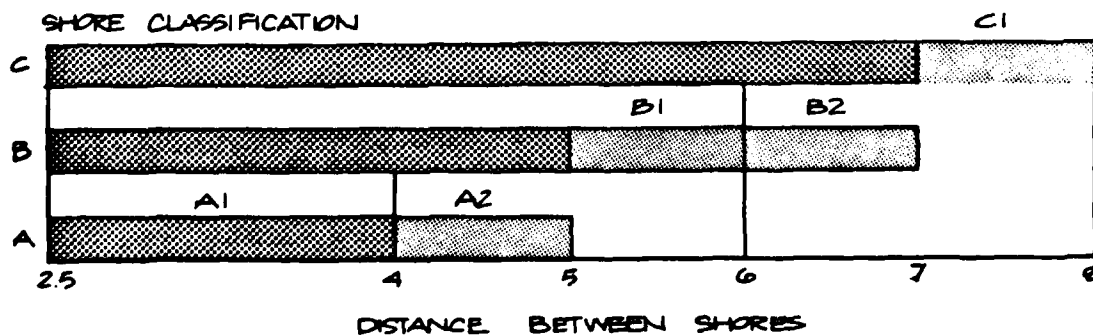
SOIL COVER	
DEPTH	PF
1.0	100
2.5	1000

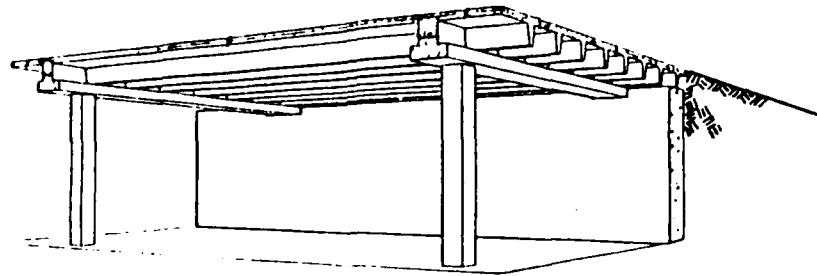
(PF = PROTECTION FACTOR)
SEE GLOSSARY

Shoring

The recommended method for shoring one-way joist and one-way slab, beam and girder is to use post and beam shores. It should be noted that posts and beam shores are to be placed under the joist and beam portions of the basement area. Post shores must be used under the main girder members.

For shore classification see spacing chart below, and for types of shores refer to pages A-3 to A-6. Maximum unshored distance should not exceed 1/4 of the span.





Double Tee

Characteristics and Construction Details

Concrete double tee construction are precast units, transported and erected at the site.

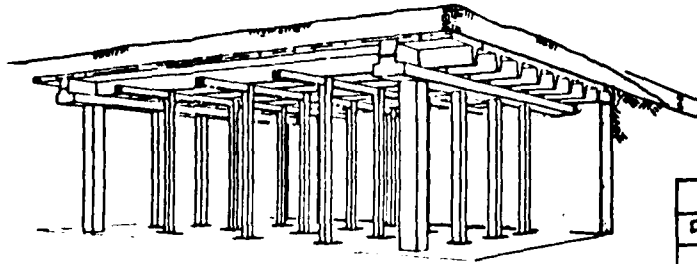
Girder beam supports are often inverted tee beams set in place, or cast with the columns.

Slab thickness usually is not less than 4 inches. Thicker slabs occur with deep, widely spaced tee stems.

Stems normally range from 16 to 32 inches deep, and double tee spans range from 18 to 30 feet.

Columns are usually square or rectangular and are usually tied to the girders.

DOUBLE TEE UPGRADING



DEPTH OF
SOIL COVER
IN FEET

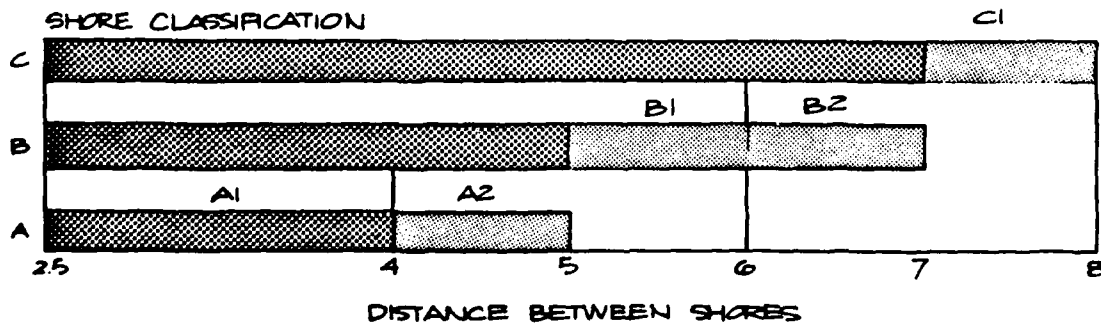
SOIL COVER	
DEPTH	P _F
1.0	100
2.5	1000

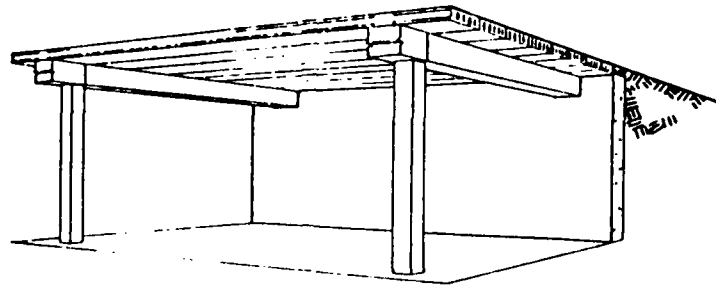
(P_F = PROTECTION FACTOR)
(SEE GLOSSARY)

Shoring

The recommended method for shoring double tee concrete construction is to use post and beam shores, with post shores under the supporting girders.

For shore classification see spacing chart below, and for types of shores refer to pages A-3 to A-6. Maximum unshored distance should not exceed 1/4 of the span.





Concrete Hollow - Core

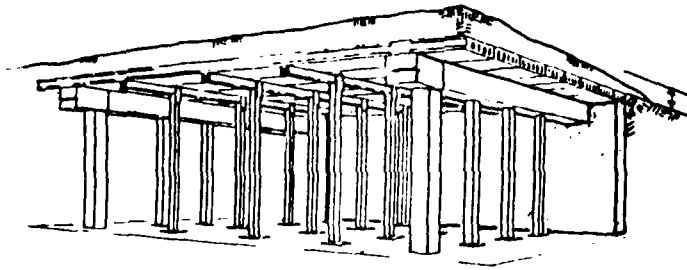
Characteristics and Construction Details

Concrete hollow-core construction is fabricated as precast slab units, with reinforcing in the longitudinal direction only. Individual slabs are placed side by side, and the deck is usually surfaced with a thin layer of concrete. Slab thickness is usually 8 to 10 inches.

The slabs are supported on girders and columns. The girders may be precast or cast-in-place. Columns may also be precast or cast-in-place.

Hollow-core spans normally range from 18 to 28 feet.

CONCRETE HOLLOW-CORE UPGRADING



DEPTH OF
SOIL COVER IN FEET

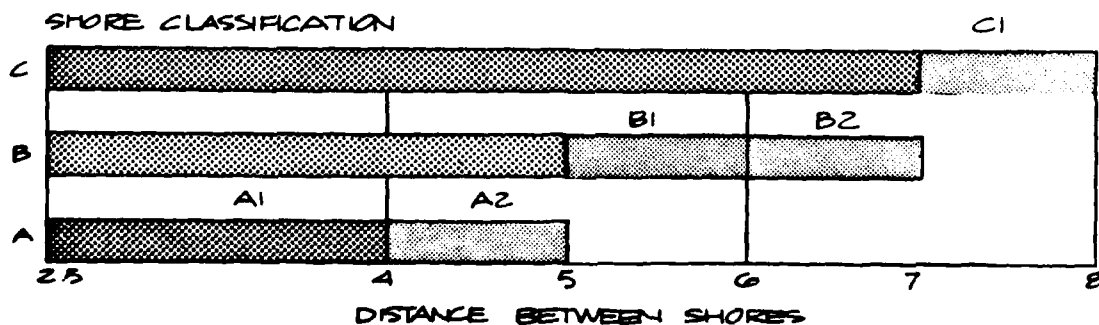
SOIL COVER	
DEPTH	P _F
1.0	100
2.5	1000

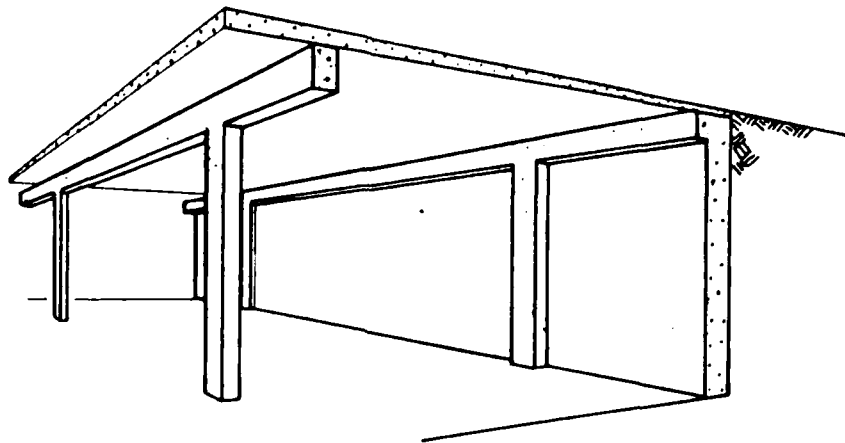
(P_F = PROTECTION FACTOR)
SEE GLOSSARY

Shoring

The recommended method for shoring hollow-core construction is to use post and beam shores under the slabs, and post construction under the supporting girders.

For shore classification see chart below, and for types of shores, refer to pages A-3 to A-6. Maximum unshored distance should not exceed 1/4 of the span.





One-Way Slab and Girder

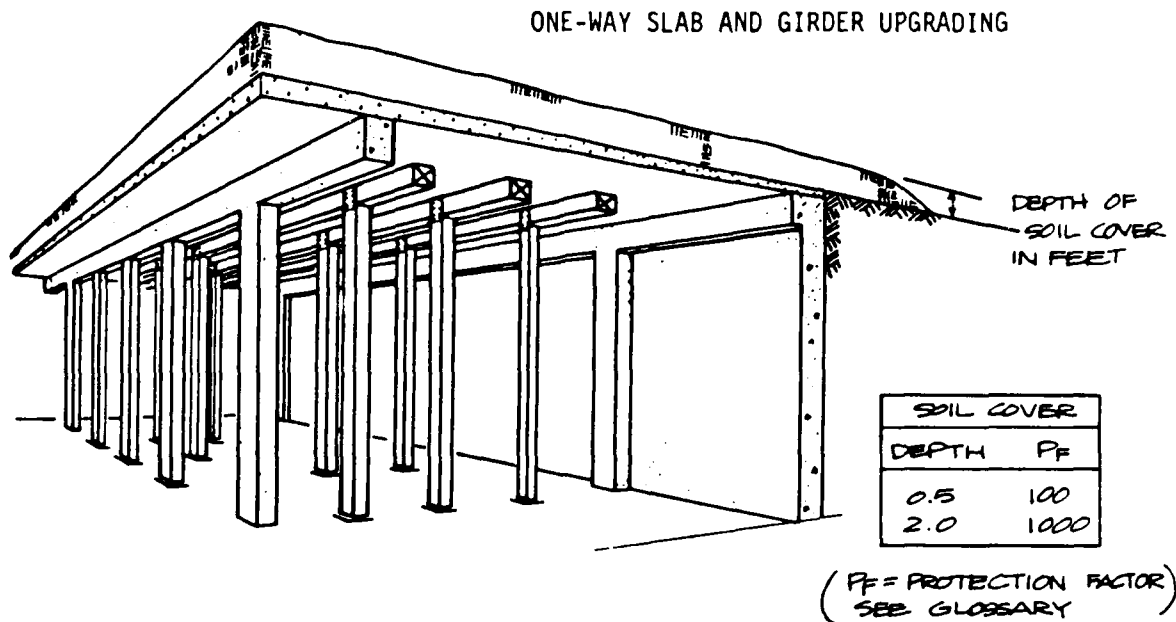
Characteristics and Construction Details

Concrete slabs are 8 to 12 inches thick, and girders are cast with the slab.

Columns are concrete and are constructed integrally with the girders. Columns are generally square or rectangular.

Girders are normally 12 inches wide or greater, and may be up to 36 inches deep in heavy, long-span structures.

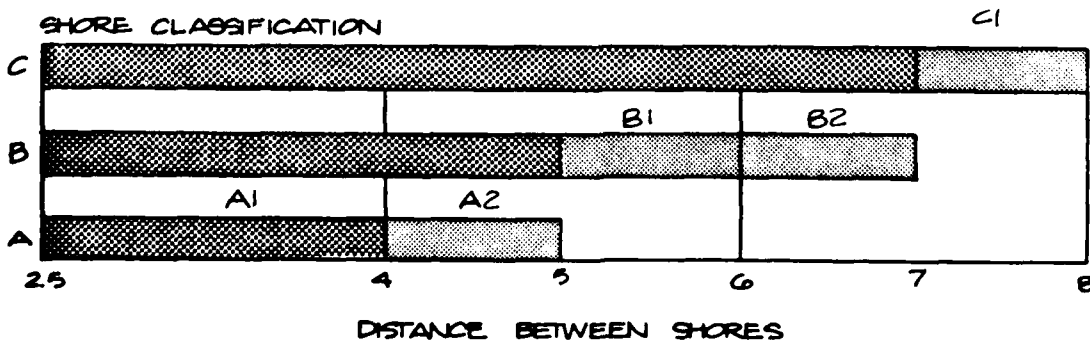
Spans between supports along the girders normally vary from 20 to 30 feet. The width between girders is usually one-half the span length or less.



Shoring

The recommended method for shoring one-way slab and girder is to use post and beam shores under the slab, as shown in the sketch above and post shores under the girder. Two lengths of shores must be provided for shoring the beams.

For shore classification see spacing chart below, and for types of shores refer to pages A-3 to A-6. Maximum unshored distance should not exceed 1/4 of the span.



STEP 4: Survey Expedient Shelters for Upgrading

Because of the limited number of existing structures that have been found to be upgradable, it will be necessary in many cases to use expedient shelters. There are many options that could be considered, including adapting onsite buried enclosures such as tanks, storm drains, utility vaults or alternatively, obtaining an enclosure that can be buried. Structures that can be buried and used as shelters include railroad cars, tanks, or specially designed shelters.

Expedient shelter options discussed here are as follows:

- Buried tanks
- Railroad cars
- Storm drain systems
- Other shelter types

Two expedient shelter checklists are provided at the end of the main text as an aid for implementing expedient shelters. These checklists are designed to assist the industry planner in shelter selection and upgrading.

The shelter options discussed herein are only a few of the potential possibilities for key worker shelters. Each plant superintendent and/or planner should survey his plant and immediate area for the best choices. The formation of mutual aid pacts with other nearby essential industries to develop key worker shelters jointly should also be considered.

EXPEDIENT SHELTER FACT SHEET

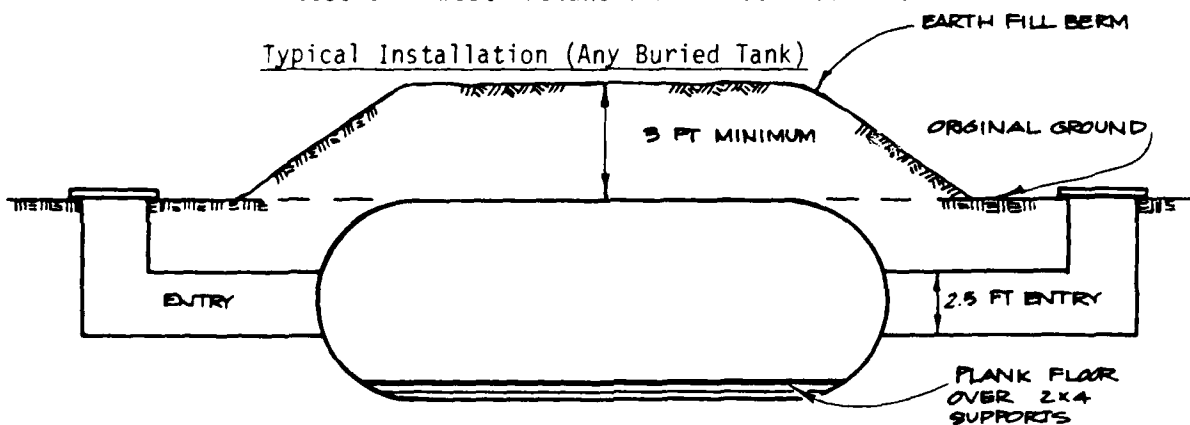
BURIED TANKS

Buried tanks provide ideal shelters and, dependent upon size, can be used for both long and short stay-times.

- (1) Pressure vessel type tanks, such as newly manufactured liquid propane or LNG type tanks, do not require upgrading.
- (2) Many other types (non-pressure) can be easily upgraded. Detailed upgrading schemes have not yet been developed.

Limitations

- (1) Do not use tanks that have been used previously for fuel storage, toxic chemicals, or other hazardous materials.
- (2) Do not bury tanks in areas where high ground water is present, as the tanks may rise out of the ground owing to fluid uplift pressures.
- (3) The number of people that can be sheltered in pressure vessels in most instances will not exceed ten.



Note: Entry can be fabricated using 30-inch diameter corrugated metal, concrete pipe, or wood framing. See section on closures.

EXPEDIENT SHELTER FACT SHEET

RAILROAD CARS

Certain types of railroad cars can provide ideal shelters without upgrading for 20 to 30 people for long and short stay-times. The railroad car options discussed are limited to those fabricated of structural steel components, as described, and would not ordinarily require upgrading:

Rail tank cars

Hopper cars, both open and closed

Gondola type cars

Notes

- (1) All cars would have their undercarriages, couplers, and miscellaneous non-essential frame materials removed.
- (2) Rail tank cars have access hatches on the top. Thus, the cars could be buried upright or on their sides.
- (3) Closed hopper cars have two compartments, and thus, two separate shelters can be provided from one car. Cars could be buried upright or on their sides.
- (4) Open hopper cars can be buried upside down, and the hopper gate modified as a shelter entrance.
- (5) Gondolas can be buried upside down, and access may then be provided through the side walls.
- (6) Heavy crane or other lifting equipment is required to place cars in excavation.

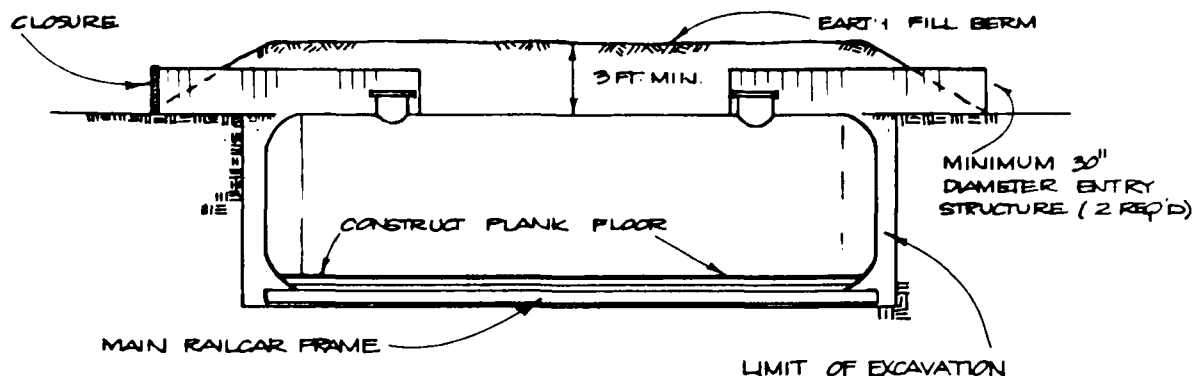
Advantages of Implementing Railcars

- (1) Railcar types suggested for expedient shelters are all constructed of steel sheet plate with heavy steel frames, hatches, and reinforcing.
- (2) Railcar bodies are readily available from car dismantler companies.

TYPICAL RAILCAR ANNUAL RETIREMENT

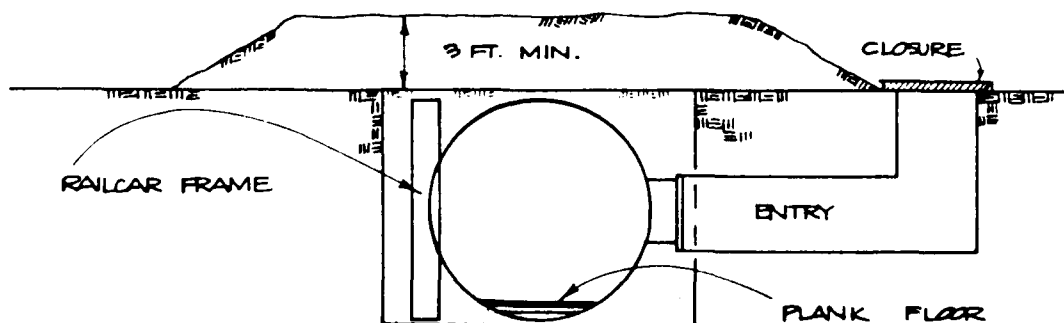
Type of Car	Total No. of Cars Retired Annually	10% of Car Bodies Usable Without Repair	20% of Car Bodies Estimated Repairable	Total Potential Car Bodies Usable
Tanks	128	13	26	39
Hopper (closed)	11,382	1,138	2,276	3,414
Hopper (open)	23,271	2,327	4,654	6,981
Gondolas	12,559	1,256	2,512	3,768
TOTALS	47,340	4,734	9,468	14,202

Details of railcars buried as expedient shelters are shown on the following pages.

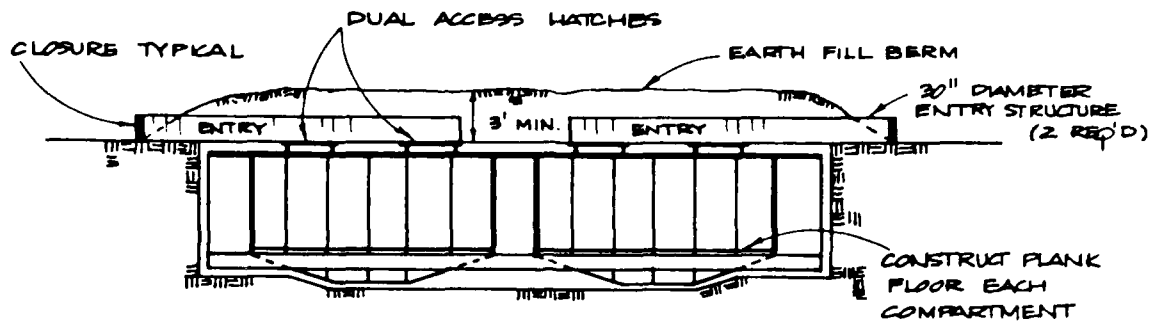


Typical Buried Railroad Tank Car

- Notes:
- (1) Railcar undercarriage and frame are removed from tank to the extent possible; otherwise bury with frame components.
 - (2) Interior floor may be constructed with plywood and 2-inch dimension lumber for framing.
 - (3) Access to car hatches may be fabricated with 30-inch corrugated metal, including elbow at hatch. A wood-framed entry may also be used. It may be necessary to remove hatches, to provide access.
 - (4) Entry structure can also be used for ventilation.
 - (5) Temporary closures are required for blast protection.
 - (6) Tank must be steam cleaned prior to burial. DO NOT USE tank cars that were previously used for fuel storage, toxic chemicals, or other hazardous materials.

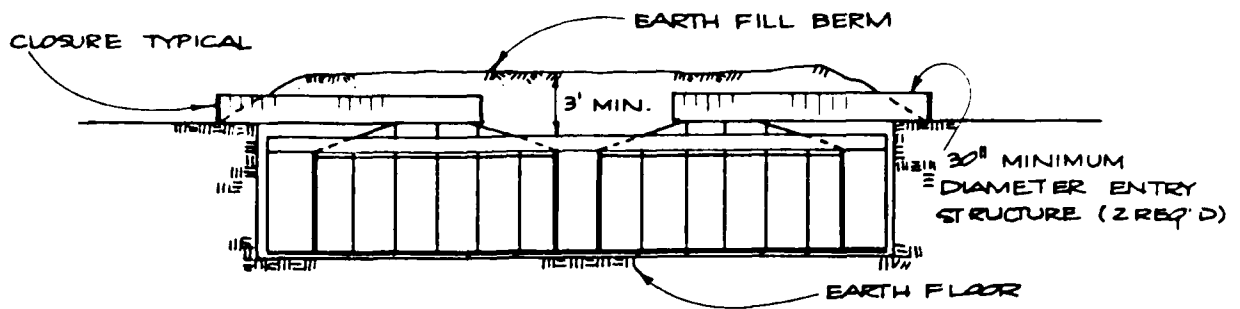


Typical Buried Railroad Tank Car - Alternate Entry Configuration (On Side)



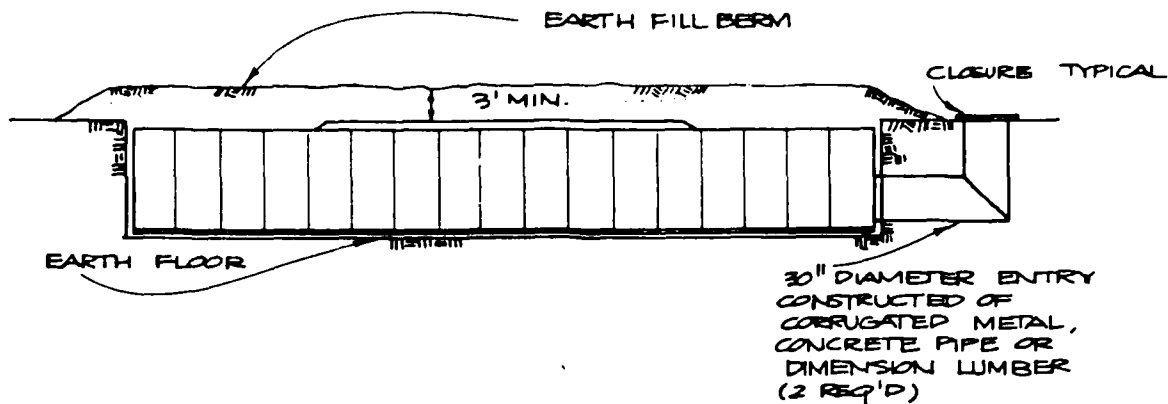
Typical Buried Closed Hopper Car

- Notes:
- (1) Railcar undercarriage and miscellaneous frame components to be removed prior to burial.
 - (2) Interior of car must have floor constructed over sloped hopper bottoms. Area below floor to provide shelter supply storage.
 - (3) Access to hatches to be fabricated of 30-inch metal pipe or wood framed. Double entry to compartment hatches for ventilation is recommended. Alternate hatch can be provided through side of car.
 - (4) Temporary closures are required for blast protection.
 - (5) Hoppers to be cleaned prior to burial.



Typical Buried Open Hopper Car (Upside Down)

- Notes:
- (1) Railcar undercarriage and miscellaneous frame components are removed prior to burial.
 - (2) Burial is upside down; earth floor is proposed; wood or other floor optional.
 - (3) Access is through hopper bottoms, or alternatively, through side of car.
 - (4) Temporary closures on entry are required for blast protection.
 - (5) Hoppers to be cleaned prior to burial.



Typical Buried Gondola Car - Upside Down

- Notes:
- (1) Railcar undercarriage and miscellaneous frame components are removed prior to burial.
 - (2) Burial is upside down; earth floor is proposed. Wood or other floor is optional.
 - (3) Access is proposed through end or sides of car.
 - (4) Temporary closures on entry are required for blast protection.
 - (5) Car interior to be steam cleaned prior to burial.

EXPEDIENT SHELTER FACT SHEET

STORM DRAINAGE SYSTEMS

Major storm drainage facilities and their components can provide shelter in key worker areas for long and short stay-times. Two components of a typical drainage system are analyzed for shelter purposes:

- o Storm drain manholes (short stay-time)
- o Major conduits — 5 feet and larger (long stay-time)

Notes

- (1) Manholes should be a minimum of 4 feet in diameter and 6 feet deep.
- (2) Manholes are often located in high volume street traffic areas and therefore, access to them may not be available in these locations. Manholes located in street medians, parking, or low-traffic areas may be more easily implemented.
- (3) Large closures are necessary at conduit ends to provide blast protection, and these closures probably cannot be fabricated in less than 72 hours without some preplanning.
- (4) All open drain inlets must be sandbagged to provide blast protection.
- (5) Some storm drainage conduits may have considerable depth of flow or be located in areas subject to tidal action, and thus should not be used for shelters.
- (6) To utilize storm drain conduits with a minimum depth of water flow may necessitate construction of false floor systems. (see Figs. 2 and 3).

Advantages of Using Storm Drain System Components as Expedient Shelters

Manholes (Short Stay-Time):

- (1) Storm drain manholes are numerous. On any major drainage system they are located from 500 to 1,000 feet apart.
- (2) They require no upgrading and are easily adapted to use as short stay-time one- or two-man shelters, with addition of a temporary wood floor and modifications to manhole lid closures.
- (3) Special ventilation equipment is not required, as ventilation naturally occurs through drain pipes at base of manhole.
- (4) If storm drains are not available near the plant, manhole sections, as shown in Figure 4, may be obtained from manufacturers, and one- or two-man shelters can be buried at the key worker site. For small key industries with fewer than five key workers, this may be a viable option.

Major Conduits - 5 Feet And Larger (Long Stay-Time)

- (1) No radiation or fallout shielding is necessary because of depth of burial.
- (2) Ventilation equipment is not needed, as the systems have natural ventilation at all inlet locations. Fabrication of blast resistant closures must be implemented also.
- (3) Long drain systems are large enough to provide shelter for more than one industrial plant.

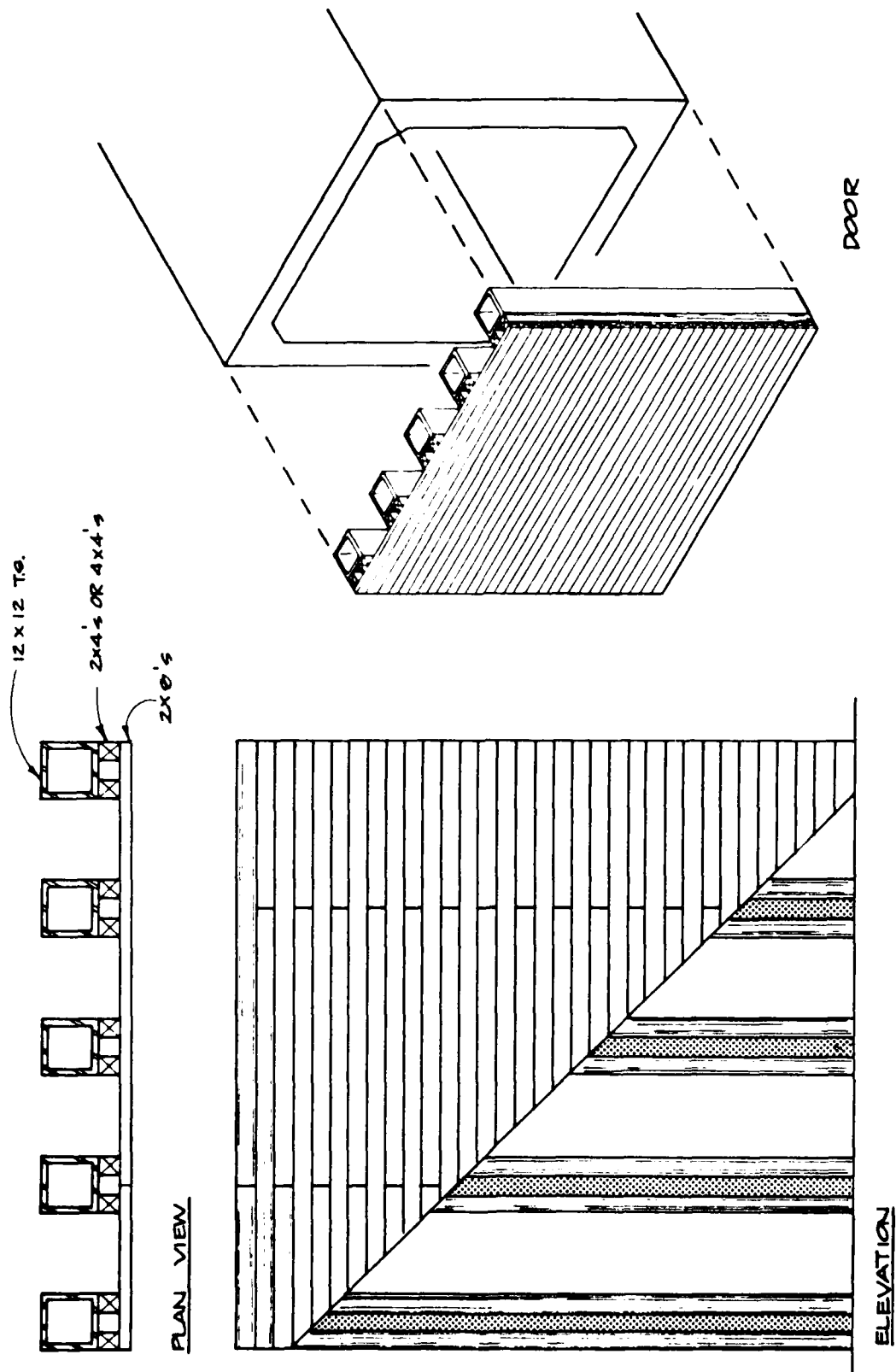


Fig. 2 . Typical Closure for a 10 ft by 10 ft Box Culvert For 40 psi.

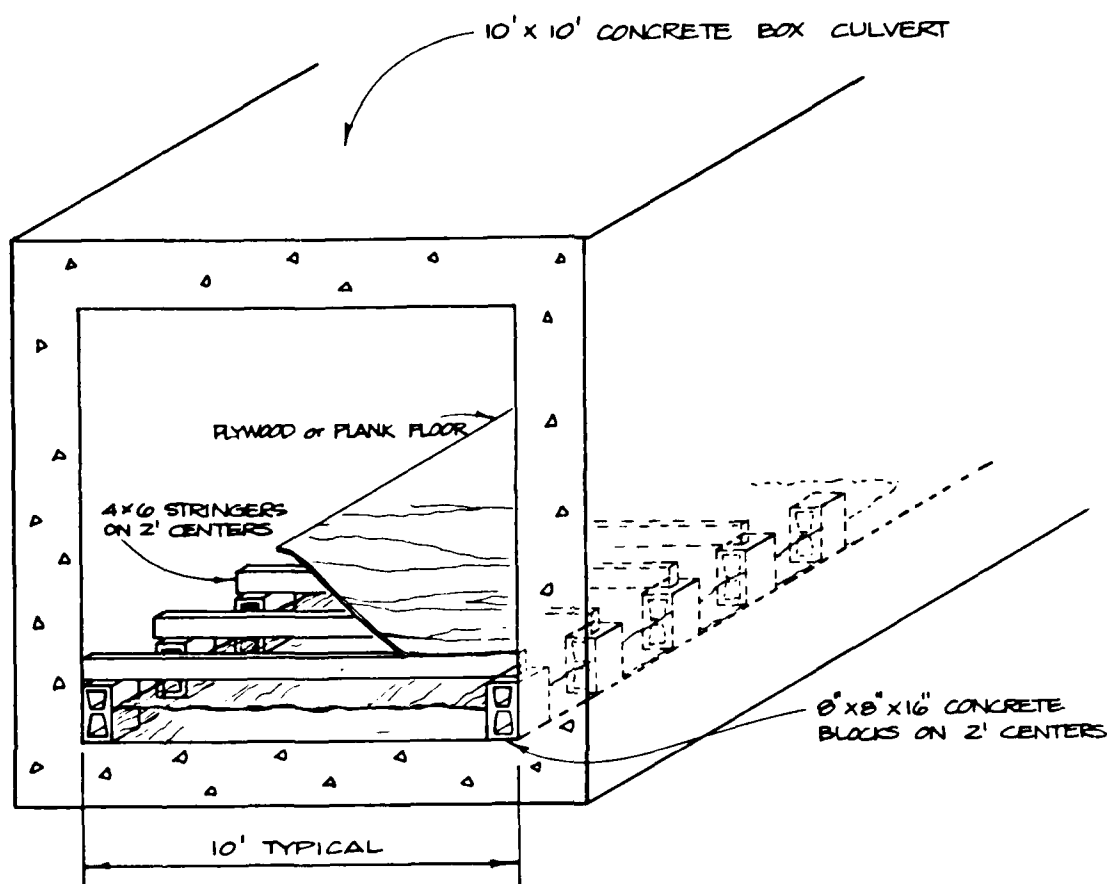


Fig. 3 Box Culvert Key Worker Shelter With Low-Flow False Floor.

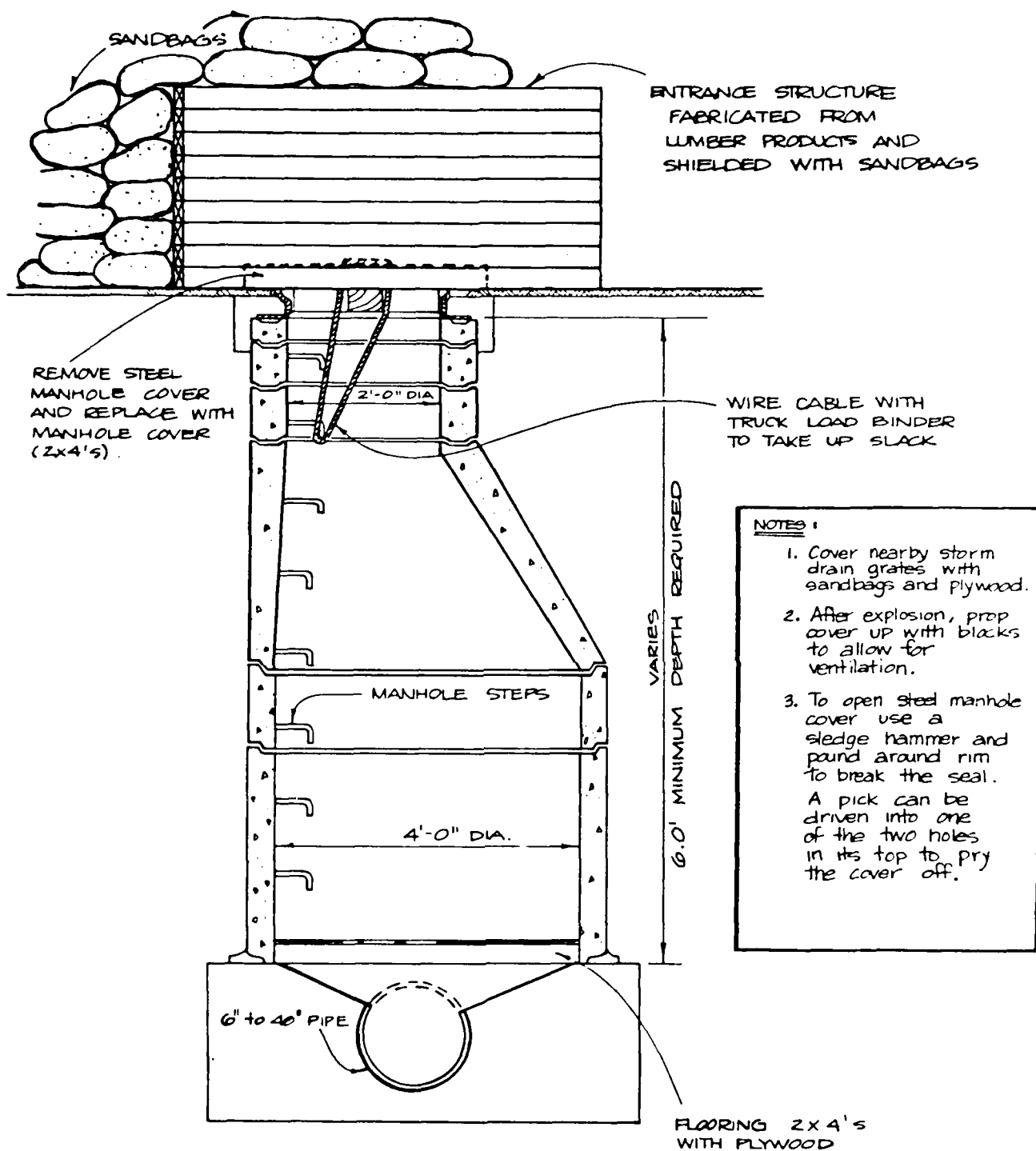


Fig. 4 . Key Worker Shelter in Storm Manhole.

EXPEDIENT SHELTER FACT SHEET

CONCRETE UTILITY VAULTS

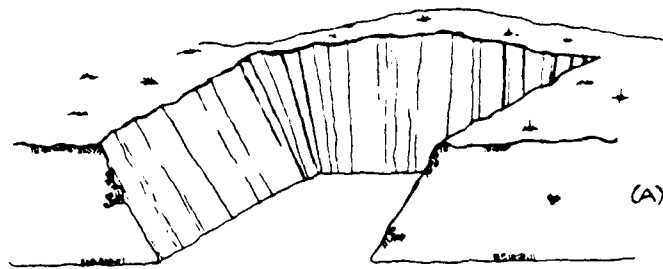
The adaptation of prefabricated underground utility vaults (the types used by telephone and electrical utilities) for key worker shelters is recommended as a valuable, practical, and easily implemented shelter option. The implementation of precast utility vault components for a shelter has been previously tested, and placement of a six-man vault and entrance structure, including covering the vault with earth radiation protection, required less than 10 hours using three men and heavy equipment.

Figures 5 and 6 show the burial of a utility vault shelter and the upgrading of various components.

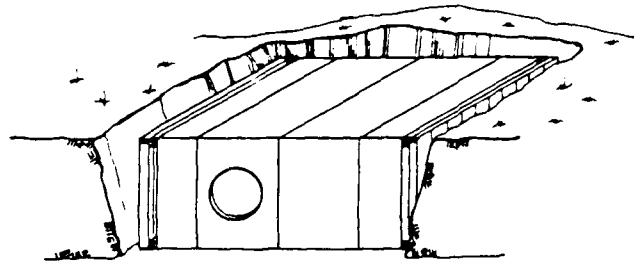
C.E.M.O. MARK II SHELTER

Previous experiments have been conducted to determine the use of a corrugated thin-walled fiberglass type cylinder structure for shelter purposes in the Dial Pack tests in 1971. The shelter survived a 40 psi blast with only minor structural damage, which was attributed to poor backfill operations. All equipment and supplies in the shelter were usable.

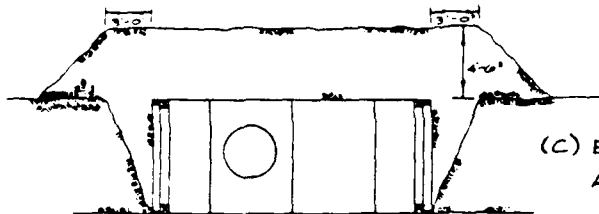
Figure 7 describes the C.E.M.O. Mark II shelter, a blast shelter developed by the Canadian Emergency Measures Organization.



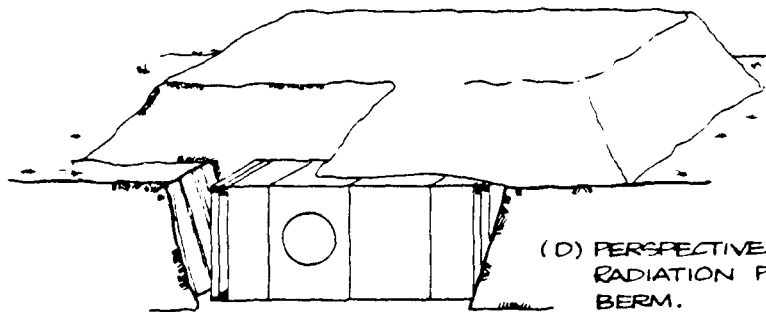
(A) EXCAVATION FOR UTILITY VAULT.



(B) VAULT IN PLACE PRIOR TO BACKFILLING.



(C) END VIEW SHOWING BACKFILL AND RADIATION PROTECTION BERM.



(D) PERSPECTIVE VIEW OF RADIATION PROTECTION BERM.

Fig. 5. Utility Vault Shelter.

ASSEMBLY DRAWING

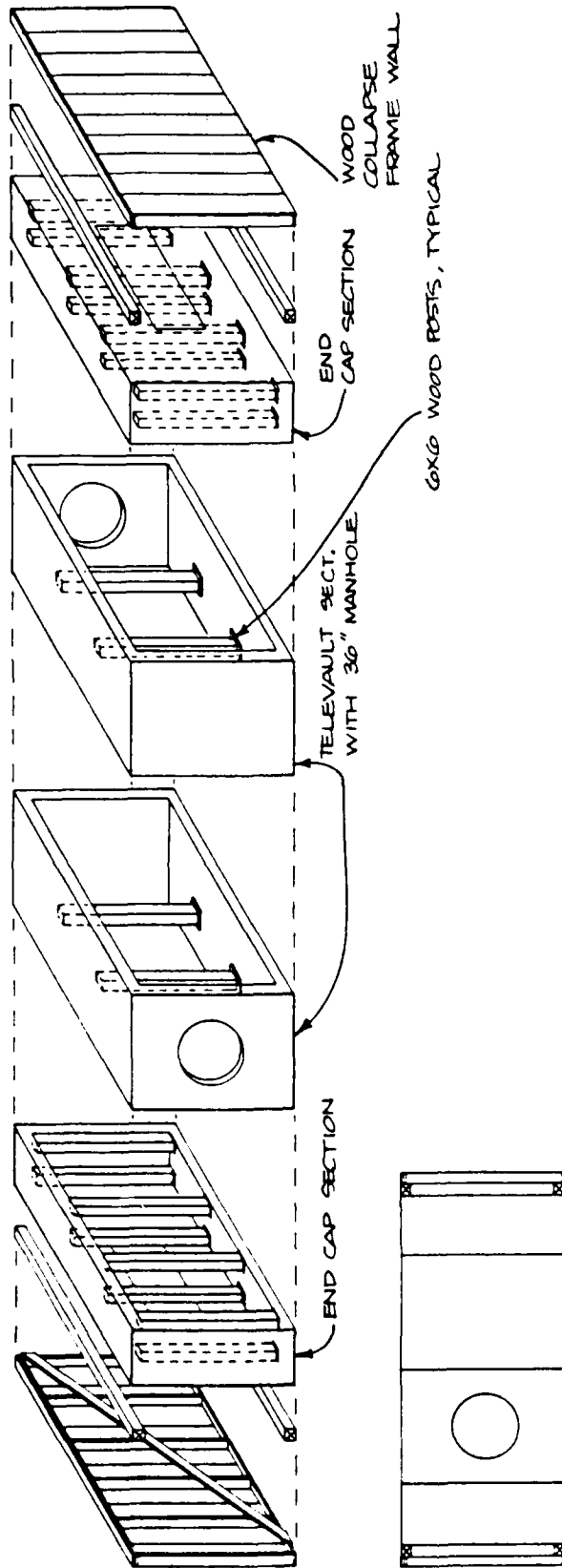


Fig. 6. Utility Vault Shelter Components, Depicting Upgrading Methods to Provide 40 psi Overpressure Protection.

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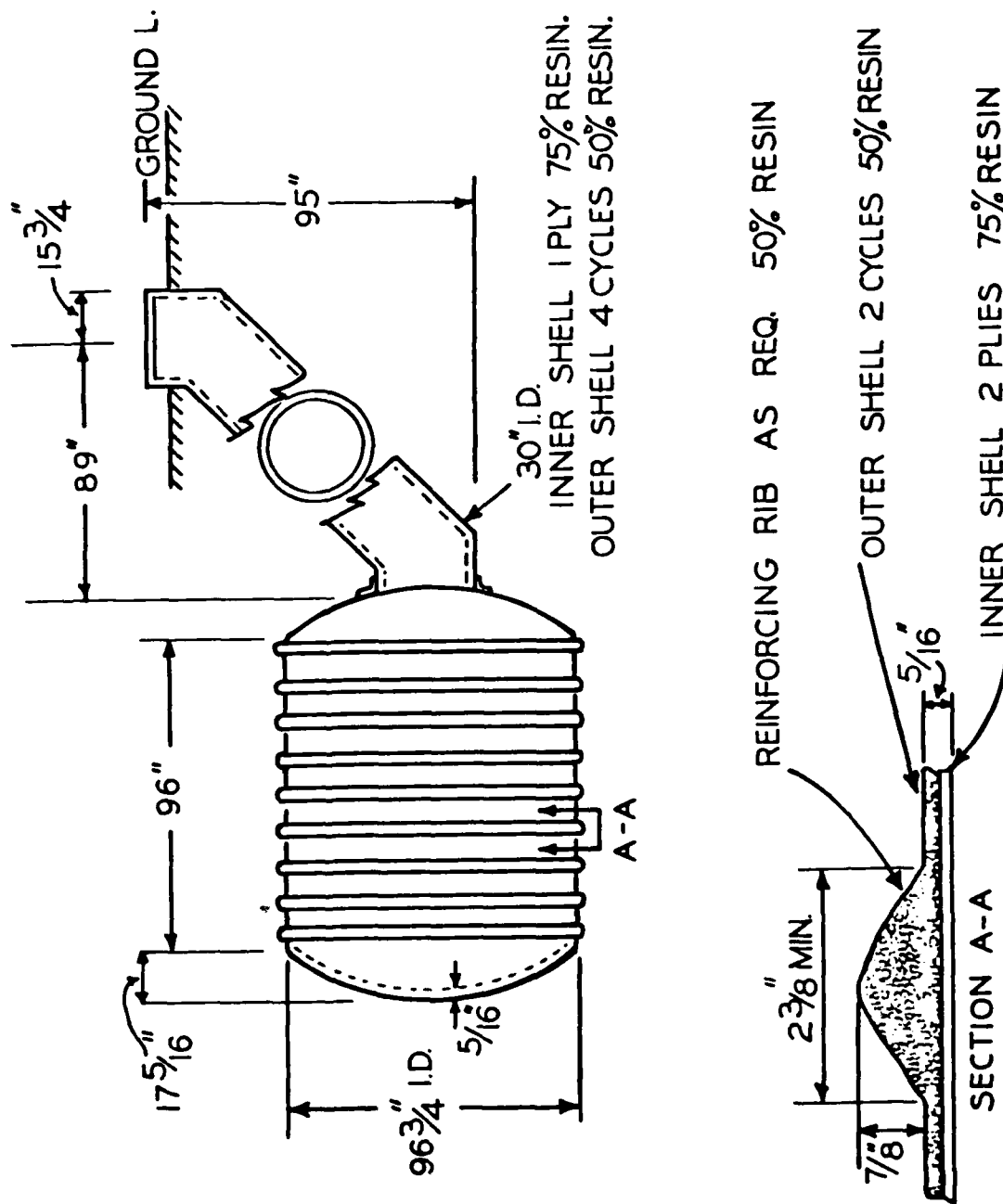


Fig. 7 C.E.M.O. Mark II Shelter Details.

STEP 5: Assess Shelter Closures and Access Alternatives

Shelter entry structures and closures are key elements in the development of 40 psi blast-resistant, key worker shelter spaces. For the upgrading of existing basement areas, main concern is to ensure suitable blast-resistant closures for existing entryways and other openings, and development of acceptable access. Acceptable shelter entry will require a shelter entry structure.

Shelter Entry Structures

The use of shelter entry structures is intended to provide a way into and out of the shelter that is both blast and radiation proof. Existing entries will not be. A typical wood construction entry structure that can be used is shown in Figure 8 and a suitable closure is shown in Figure 9.

As an alternative to wood construction, concrete pipe or corrugated metal pipe entry structures may also be fabricated. Figure 10 shows such a typical structure, and Figure 11 is a suitable closure for a circular entry structure.

Closures

The majority of shelter spaces will require some form of closure in addition to entry closures. Any basement upgraded for a key worker shelter will probably have a stairway, windows, doors, ventilation ducts, or access openings.

These openings can be bridged by using a number of readily available materials, such as wood or steel. Examples of wood that may be used are fence posts, spare power poles (cut up), railroad ties, solid core doors, and wood beam and plank pieces. Steel plate and rolled beam sections may also be used. Table 1 (page 44) lists alternative materials that may be considered for closures.

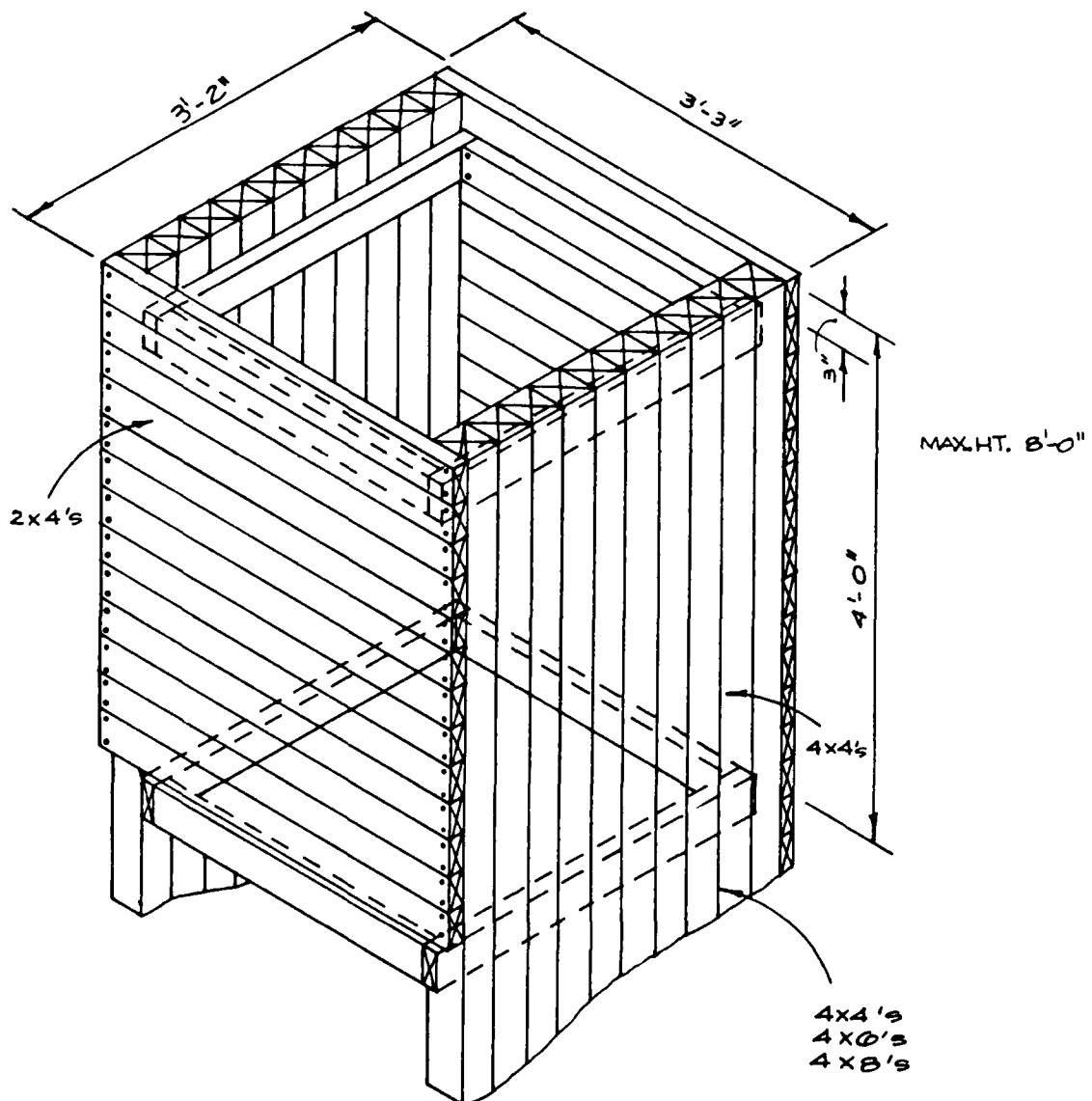


Fig. 8. 40 psi Entrance Structure to Key Worker Shelter (Wood Construction).

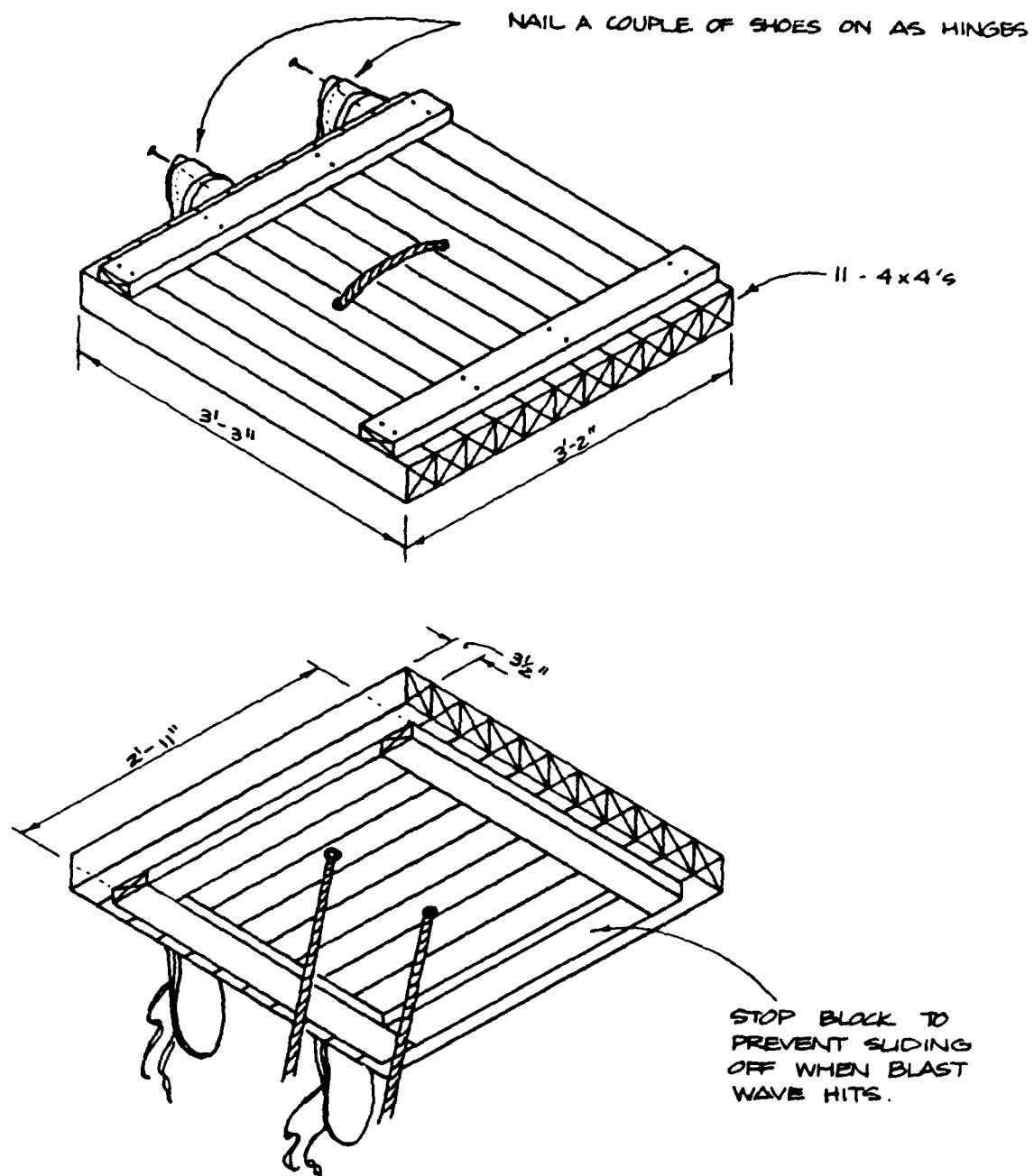


Fig. 9. Closure for 40 psi Entrance Structure to Key Worker Shelter (Wood Construction).

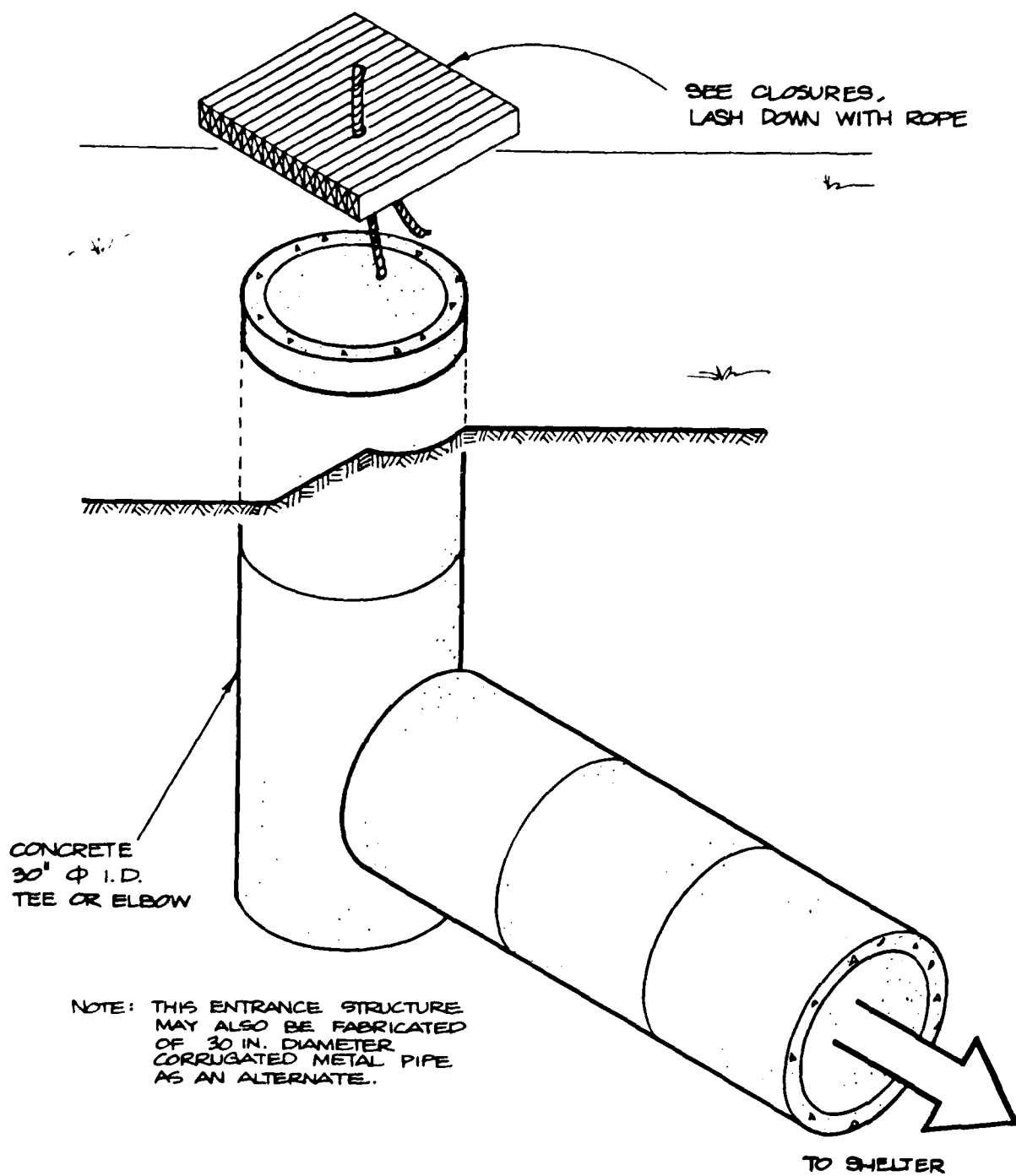


Fig. 10. 40 psi Entrance Structure to Key Worker Shelter (Concrete Pipe Construction).

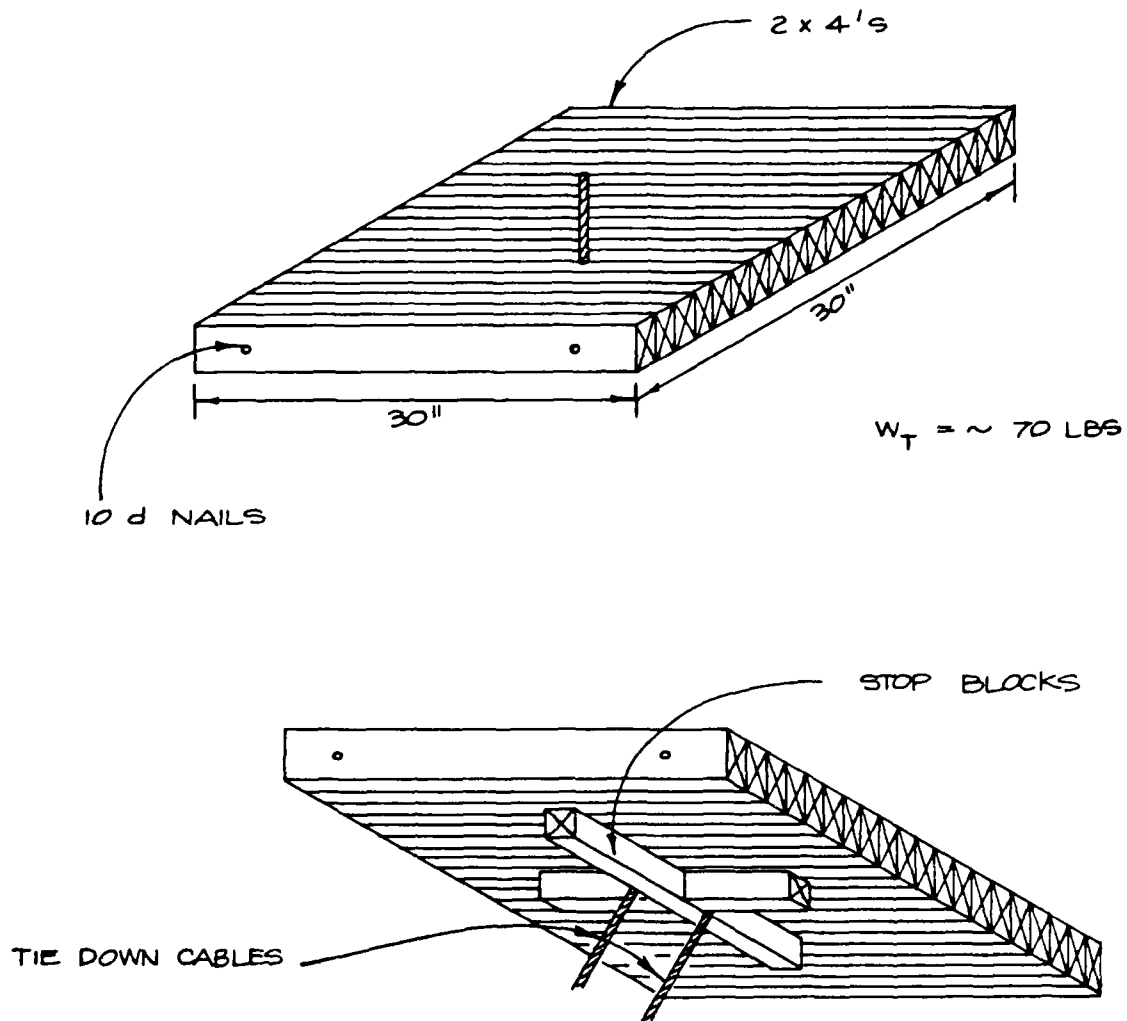


Fig. 11. Expedient Manhole Closure, Key Worker Area.

TABLE 1: CLOSURE MATERIALS

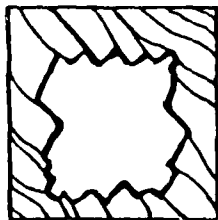
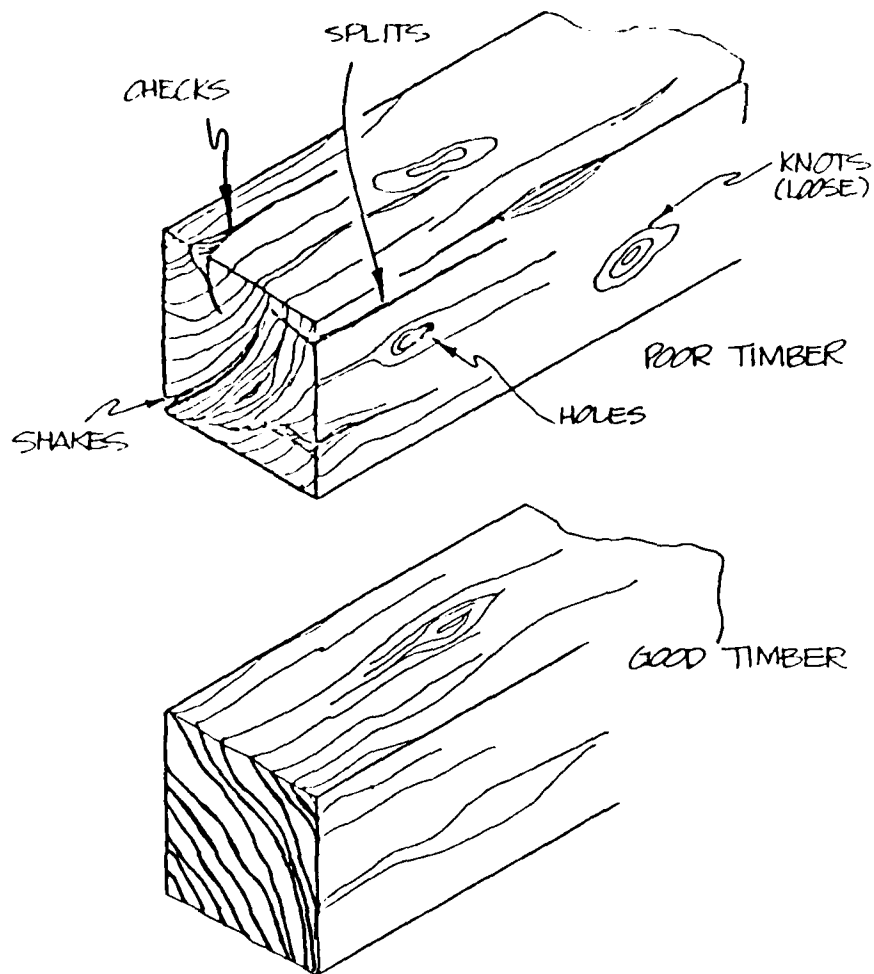
Steel doors	Telephone or power poles
Wood doors (solid)	*Filled sandbags
Toilet doors and partitions	*Filled paper bags
Steel cover plates	*Filled paper boxes
Desk and table tops	*Filled plastic garbage cans
Railroad ties	Brick or concrete block
Plywood	*Filled oil or paper drums
Wood, steel, or concrete fence posts	
	*filled with sand or earth

The use of wood products for closures requires that material variations affecting wood strength be considered. Wood fence posts, power poles, or railroad ties may be splintered or may exhibit rot or other defects. Generally, poor timber may have checks, shakes, or splits. These features are illustrated in Figure 12.

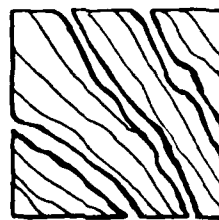
Comparison of various materials that may be used to construct both horizontal and vertical closures is shown in Figure 13. This figure indicates the maximum opening width that may be spanned without intermediate support for various materials. This chart can be used in two ways:

1. Enter the chart with the minimum opening width, and list the type and thickness of materials that could be used for closures. Then, select the most available materials from the list; or --
2. Enter the chart with a known available resource and determine the width of closure that may be accommodated. This alternative will indicate if a further search for closure resources is required.

As an example, assume a basement shelter has two openings -- one vertical opening that is 18 inches in diameter, and the other, a horizontal opening 30 inches by 40 inches. The shortest dimensions are 18 inches and 30 inches, respectively. Entering the chart from the left with these dimensions yields the



ROTTED TIES OR POSTS



SPLINTERED POSTS / POLES / TIES

Fig. 12. Factors Affecting Wood Strength.

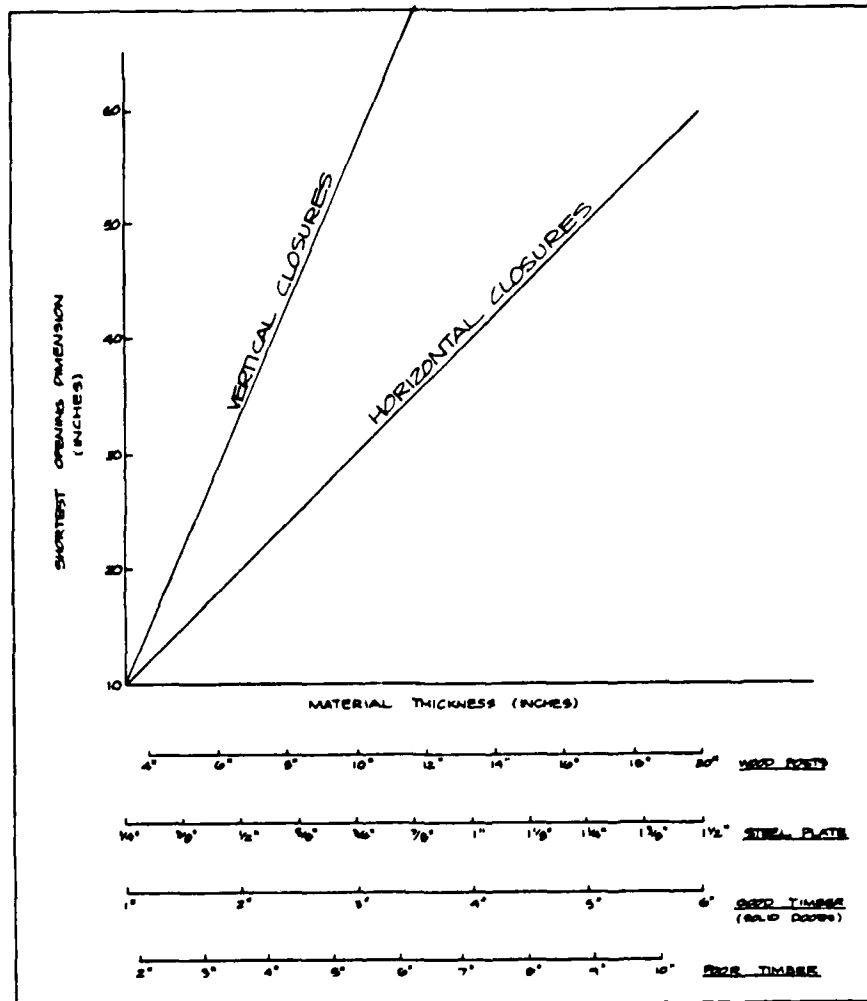


Fig. 13. Material Thickness Required to Close Various Openings (40 psi).

following list of alternative closure materials:

18-inch Diameter	30 inches by 40 inches
4-inch wood post	10-inch wood post
3/8-inch steel plate	3/4-inch steel plate
2-inch timber (good)	3-inch timber (good)
3-inch timber (poor)	6-inch timber (poor)

With these lists, available resources can be compared and determined.

It must be remembered that all shelter closures also require radiation protection. The most straightforward approach is placing earth over the closure if it is horizontal, or piling earth against the closure if it is vertical. The earth placement may require significant personnel time or earth-moving equipment, particularly over basement floors enclosed by structural improvements. One expedient method is to place the earth (or sand) in containers such as sandbags, paper bags, cardboard boxes, or other containers.

Figures 14, 15, and 16 illustrate different types of basement closures and placement of earth radiation protection.

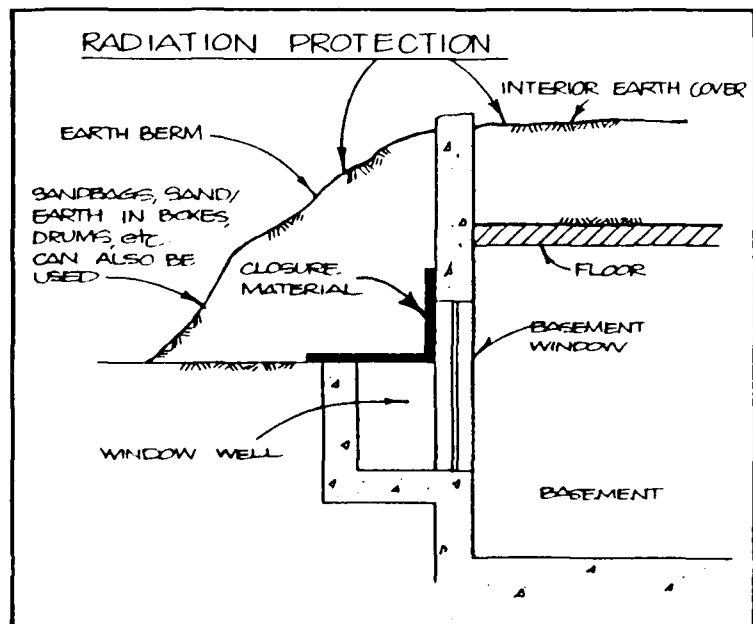
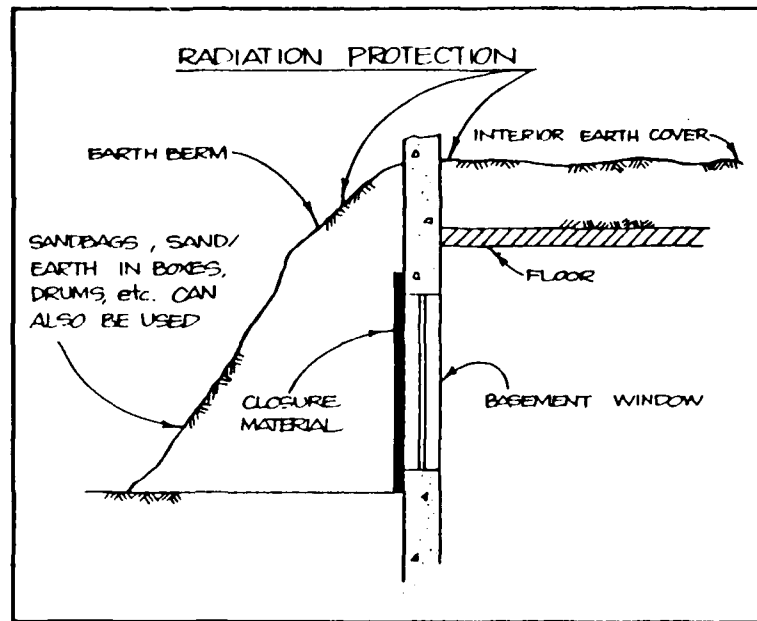


Fig. 14. Window Closures.

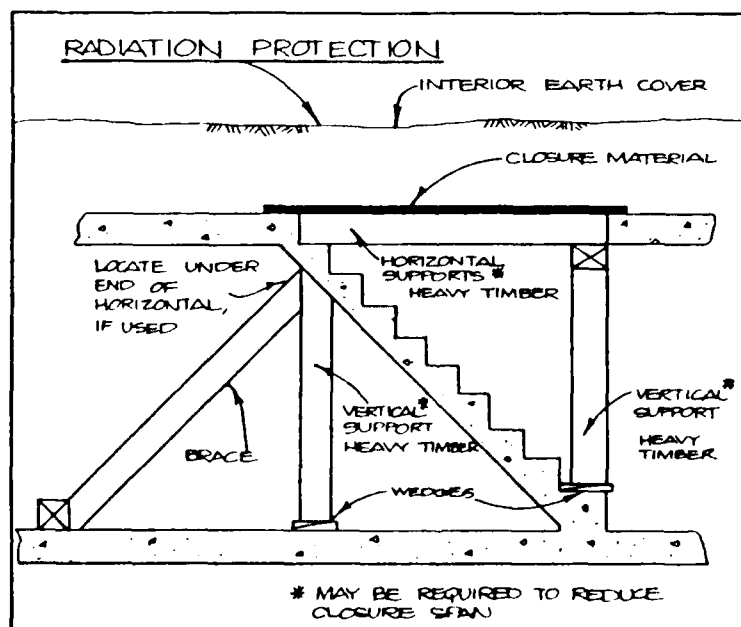
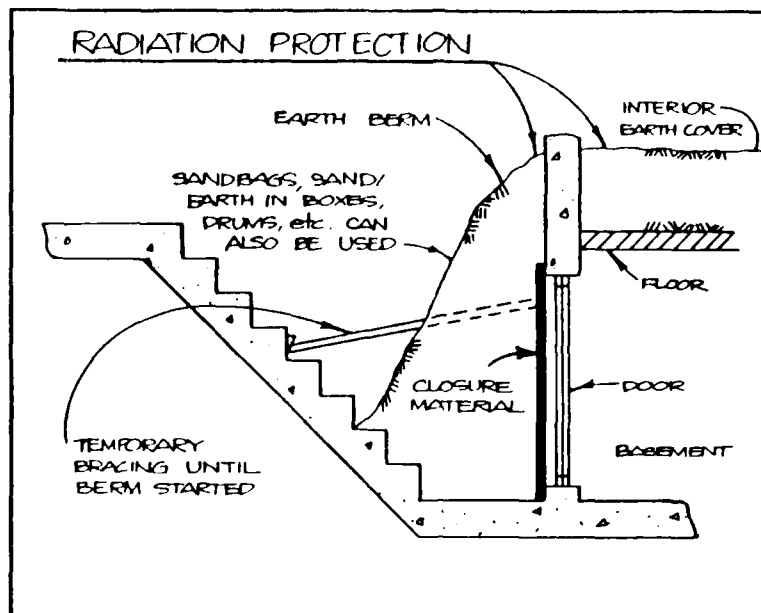


Fig. 15 . Stair and Door Closures.

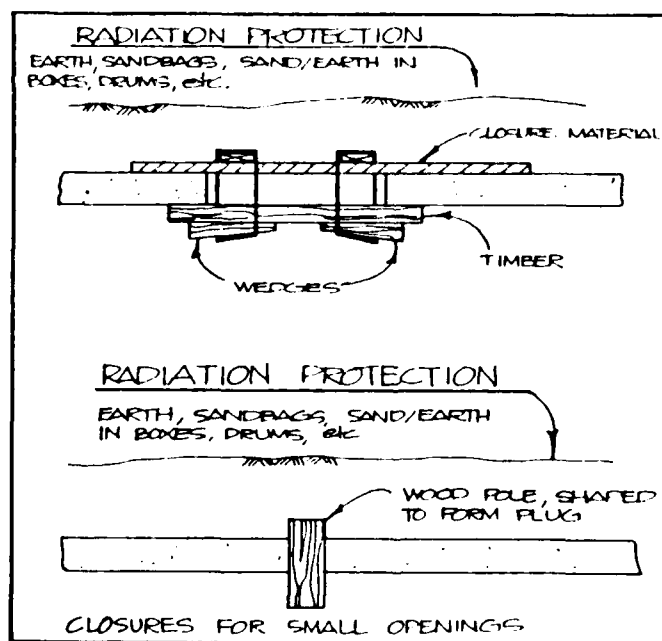
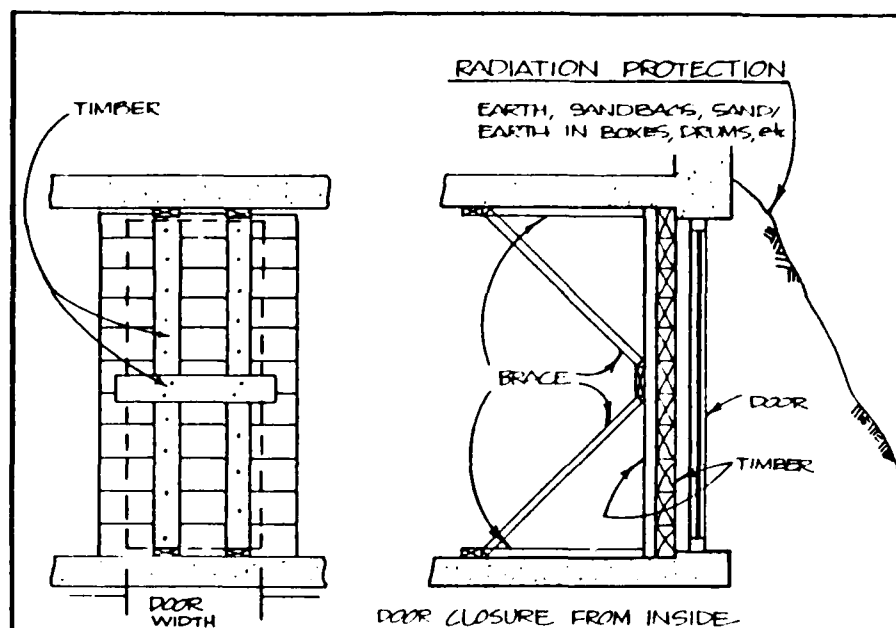


Fig. 16 Door and Small Opening Closures.

STEP 6: Assess Shelter Stocking

Provision for emergency food, medical, and other supplies must be made, since warning of an impending nuclear attack may not allow for last-minute purchases. Each key worker shelter established for long stay-time should be provided with a minimum of two weeks food and water for each key worker.

Water. -- An adequate water supply is even more important to survival than an adequate food supply. An individual can survive for four weeks without food, but could not survive more than a few days without water or similar fluids. Moreover, tests completed on groups living under shelter conditions have shown that limiting fluids to the amount considered necessary for survival can cause considerable discomfort and is more critical than crowding, heat, or boredom.

The minimum water each individual should be provided for survival is one gallon per day -- one-half gallon for drinking and one-half gallon for other purposes. The water can be stored in containers in the shelter, or connected to an external storage source independent of municipal supply systems.

Food -- The most important factors to be considered in providing an adequate food stockpile are nourishment (food value in relation to volume), long shelf life, and ease of preparation. Of less importance are palatability and cost. A balanced diet is not necessary, since the stockpile is intended to be used for only a limited period of time.

Foods that require little space for storage, that keep for months without refrigeration, and that require little or no cooking are best. Cans and jars sized to meet requirements for single meals are best, as some foods deteriorate rapidly after a container is opened. Foods canned in metal or glass will stay in good condition for six or more months if kept in a dry, cool place (preferably, not above 70°F or below freezing). Replace canned foods with a fresh supply at least once a year and foods in paper boxes without added protection at least every three months.

Table 2 lists foods that are best suited for shelter supplies. The table is designed to specify foods necessary under three different stay-times. The quantities shown in the list are sufficient for one adult and supply 2,000 calories per day.

Other Supplies -- In addition to food and water there are a number of other essential supplies that should be stocked in the shelter. The requirements for these items are listed in Table 3 for three shelter stay-times.

An operating battery-powered radio is an essential part of an effective shelter. Since radio reception is cut down by the shielding necessary to keep out radiation, as soon as the shelter is completed a radio reception check must be made. It will probably be necessary to install an outside antenna to receive CONELRAD broadcasts, which are much weaker than normal broadcasts.

Fire extinguishers should be easily accessible and available inside shelters, and should not affect the breathability of the air when used.

Waste Disposal -- If stay-times in shelters exceed 72 hours, all stored garbage and human wastes should be buried under a minimum of 12 inches of earth to discourage insects and animals from disturbing the wastes. Burial should take place when safe shelter emergence is possible.

TABLE 2. REQUIRED WATER AND FOOD SUPPLIES PER KEY WORKER

Food Item	Long Stay-Time up to 2 weeks	Short Stay-Time	
	Stock per person	24 to 72 hrs Stock per person	24 hrs or less Stock per person *
<u>Water</u> - Stored in a dark place in clean containers with tightfitting lids. Rinse and refill containers every 3 months.	14 gals	6 qts	4 qts
<u>Milk</u> - Nonfat, dry	20 oz	1 cup	* For 24 hrs or less, water alone is sufficient.
Evaporated	14 oz	3 oz	
<u>Juices</u> - Tomato, grape, apple. In crown capped bottles only. Store upright.	64 oz	1½ cup	
<u>Fruit</u> - Applesauce, pears, peaches. In glass jars, glass lids only. Store upright.	112 oz	1½ cup	
<u>Vegetables</u> - Corn, peas, beans, spinach	112 oz	--	
<u>Soups</u> - Canned or dehydrated (in can)	112 oz	1½ cup	
<u>One-Dish Meals</u> - Canned goods including chicken and rice or noodles, pork and beans, baked kidney beans, chile con carne, and beef stew.	208 oz	3 pints	
<u>Spreads</u> - Jam, jelly, marmalade	14 oz	--	
Peanut butter	14 oz	3 oz	
<u>Crackers</u> - In glass or cans	56 oz	12 oz	
<u>Beverages</u> - Instant coffee or tea, cocoa	4 oz	--	
<u>Sugar</u>	4 oz	--	
<u>Hard Candies</u>	16 oz	--	
<u>Salt</u>	4 oz	1 oz	
<u>Sterno</u>	4 cans	1 can	

TABLE 3 . KEY WORKER ESSENTIAL SUPPLIES

	Long Stay-Time up to 2 weeks	24 to 72 hrs	Short Stay-Times 24 hrs or less
Cooking & Serving Equipment:			
Cups	X	X	-
Bottle opener	X	-	-
Plates	X	X	-
Matches	X	X	X
Can opener	X	X	-
Eating utensils	X	X	-
Pocket knife	X	X	X
Clothing & Bedding:			
Towels	X	X	-
Sleeping bags	X	X	-
Spare clothing	X	-	-
Sanitation Supplies:			
Soap	X	X	-
Toilet tissue	X	X	X
Paper towels	X	X	-
Disinfectant (chlorine, bleach)	X	X	-
Insecticide	X	-	-
Garbage can	X	X	-
Human waste can	X	X	-
Emergency toilet	X	X	-
Plastic bags with ties	X	X	X
First aid kit (large)	X	X	-
Tools & Miscellaneous Items:			
Candles	X	X	X
Hammer	X	X	X
Wrench	X	X	-
Bucket	X	X	X
Shovel	X	X	X
Pliers	X	X	-
Screwdriver	X	X	-
Brooms (small)	X	X	-
Batteries	X	X	X
Flashlight	X	X	X
Calendar	X	X	-
Clock or watch	X	X	X
Axe	X	X	-
Crowbar	X	X	X
Emergency generator, fuel oil, & oil with necessary cords, plugs, lights-Hardened to 40 psi			
	X	X	-
Radio	X	X	X
Radiological monitoring equip- ment			
	X	X	X

TABLE 3 (contd). KEY WORKER ESSENTIAL SUPPLIES

	Long Stay-Time	Short Stay-Times	
	up to 2 weeks	24 to 72 hrs	24 hrs or less
Evacuation Supplies:			
Gasoline	X	X	X
Tent	X	X	-
50-mile map of area	X	X	X
Small motorcycle	X	X	X

STEP 7: Complete the Key Worker Shelter Implementation Analysis

There will likely not be more than three days available after the evacuation warning in which to implement a key worker shelter. The optimum situation is to implement beforehand, but it has been found possible to implement a short stay-time key worker shelter in one day. To determine feasibility of "last-minute" implementation, advance planning and preparation are required. The attached form provides a quick status or summary report to help prepare a schedule.

SHELTER IMPLEMENTATION

CHECKLIST A

Company Name and Address _____

Number of Key Workers Needing Shelter _____

1) Is a potential shelter available?

- a) Underground basement structure _____
- b) Existing buried structure - Onsite _____
 Adjacent off site _____
- c) New option to be buried: Tank _____
 Railcar _____
 Vault _____
 Other _____

2) Transportation to site (Expedient Shelter):

Easily relocated _____

Special transportation required _____

3) Type of transportation equipment needed:

- (a) _____
- (b) _____

4) Space upgrading - Length _____ Width _____ Height _____

- a) Type of upgrading - Post & Beam* _____
- b) Number of exits, windows, and other passages for closures required?

Dimensions: _____ x _____
 _____ x _____
 _____ x _____
 _____ x _____

* Post and beam upgrading of expedient shelters will allow a more efficient use of shelter space.

CHECKLIST A (contd)

c) Ventilation equipment

Is shelter space adequately ventilated? _____

Can shelter space be adequately ventilated? _____

Are ventilation resources available? _____

5) Upgrading resources

a) Are lumber and other materials available for upgrading? Yes ____ No ____

Locally? ____

b) Are tools and equipment available for upgrading? ____

Locally? ____

6) Is burial site available? _____

a) Is potential debris pileup a problem? _____

b) Is high ground water a problem? _____

7) Is secure storage for resources, materials and tools available? _____

CHECKLIST B

EXPEDIENT SHELTER STRUCTURE IMPLEMENTATION CHECKLIST FOR BURIAL

Expedient shelter has been delivered to key worker plant site for burial.

- (1) Select location for burial away from buildings that may collapse or from facilities that may inundate or damage entry or ventilation equipment.
- (2) Excavate for shelter using:
 - (a) Backhoe
 - (b) Front endloader
 - (c) Crawler tractor
 - (d) Combination of above.
- (3) Excavate for entries — Two are required.
- (4) Provide all modifications to structure for entries and ventilation, and clean structure interior.
- (5) Set structure in excavation with crane or other lift equipment.
- (6) Install entry, ventilation, and closure structures.
- (7) Install interior floor, if required.
- (8) Provide all large shelter stock items prior to backfilling.
- (9) Backfill and berm structure.
- (10) Finish stocking shelter.
- (11) Locate and excavate shelter waste disposal site.

GLOSSARY AND LIST OF NOTATIONS

- AS BUILT — Structure prior to upgrading
- UPGRADING — Strengthening of a structure to withstand unusual (larger than normal) loads
- HARDENING — Any activity that will reduce vulnerability
- BLAST WAVE — A wave of sudden pressure change that moves outward from an explosion, creating larger than normal loads
- OVERPRESSURE — The sudden pressure change caused by a blast wave, measured in psi. One psi is equivalent to a column of water 2.3 feet high or a column of soil 1.4 feet high
- RISK AREA — Region that is subjected to blast pressures over 2 psi
- HOST AREA — Region that is subjected to blast waves with pressures of 2 psi or less
- KEY WORKER SHELTER — A shelter that will protect the inhabitants to 40 psi or better (equivalent to a column of water 92 feet high, or a column of soil 57 feet high)
- P_f — Protection Factor (radiation). A number that indicates how many times less severe the effect of radiation is in a shelter than that received when there is no protection
- PSF — Pounds per square foot (an indication of pressure loading; a one-foot thick layer of soil would apply a pressure of about 110 psf)
- PSI — Pounds per square inch (144 psf = 1 psi)

APPENDIX A

UPGRADING DETAILS

Appendix A

UPGRADING DETAILS

This appendix supplements the upgrading information described in the manual. Tables A-1 and A-2 are intended to provide additional data and details required for shoring. A number of important facets of upgrading are presented below.

Shelter Upgrading Considerations

- o Placement of some shoring systems will be difficult to do manually because of weight problems.

Wood posts larger than 10 inches by 10 inches and longer than 8 feet will weigh more than 200 lb per post.

Nearly all steel post 12 feet in length exceed 200 lb per post; the maximum weights can be 350 lb.

- o Post lengths are limited to 12 feet, since most basement areas are not expected to exceed this height.

- o When using post and beam upgrading methods, **use steel beams only.**

Wood beams cannot be used for upgrading, because of crushing of the beam fibers.

Steel beams will require a forklift or other equipment to hoist the beams and hold them in place for placement of the post shores.

- o Details of post shores and post and beam shores are shown in Figs. A-1 and A-2. Additional information is given below.

Steel bearing plates (Fig. A-1) are required on all steel beams where floor loads are transmitted to the beams by tee-beam (Fig. A-2) or one-way joist types of construction. Bearing plates are not required between the beams and hollow-core slabs.

Steel bearing plates should be tack welded to the steel beams/columns as shown in Fig. A-2. Bearing plates should be as wide as the steel beam flanges, and minimum lengths as specified in Table A-2.




Steel shores will require bearing plates welded on both ends of the shore.

The length of the steel shore should be carefully measured and cut with bearing plate thickness allowance considered. Total length should allow for placement of wedges to provide a tight fit.

All posts will need to be placed in vertical position, moved laterally into place, and held vertically until wedges are placed.




Steel post shores require steel wedges, and wood post shores require wood wedges. Two wedges are required at each shore in order to provide a tight fit and assure uniform bearing.

TABLE A-1: SHORE DESIGNATION

STRUCTURAL TYPE AND DIMENSIONS ↓ SHORE SPACING →	MAXIMUM SHORE LENGTH - FEET				
	TYPE A		TYPE B		TYPE C
	A1	A2	B1	B2	C1
	* to 4' x 4'	4' x 4' + 5' to 5'	5' x 5' + to 6' x 6'	6' x 6' + to 7' x 7'	7' x 7' + to 8' x 8'
WOOD POST (NOM.)					
6" x 6" 6" x 8" 8" x 8" 8" x 10" 10" x 10" 12" x 12" 	8' 9' 14'	7' 11' 12'	10'	12'	12'
STEEL PIPE					
STANDARD STRENGTH 4" x 0.237" 5" x 0.258" 6" x 0.280" 8" x 0.322" 	8' 12'	12'	12'	8'	
EXTRA STRONG 3/2" x 0.318" 4" x 0.337" 5" x 0.375" 6" x 0.432"	10' 12'	12'	12'		
DOUBLE EXTRA STRONG 3" x 0.600" 4" x 0.674" 5" x 0.750"	10'	12'	10'	12'	
STRUCTURAL STEEL TUBE					
4" x 4" x 3/16" 4" x 4" x 1/4" 4" x 4" x 5/16" 4" x 4" x 3/8" 4" x 4" x 1/2" 	10' 12' 12' 12'	8' 10' 12'	8'		
5" x 5" x 3/16" 5" x 5" x 1/4" 5" x 5" x 5/16" 5" x 5" x 3/8" 5" x 5" x 1/2"	12'	12' 12'	8' 12' 12'	10'	



*minimum shore spacing should not be less than 30" (2.5') on centers under most austere conditions.

TABLE A-1: SHORE DESIGNATION (contd)

STRUCTURAL TYPE AND DIMENSIONS 	MAXIMUM SHORE LENGTH - FEET				
	TYPE A		TYPE B		TYPE C
	A1	A2	B1	B2	C1
SHORE SPACING 	* to 4' x 4'	4' x 4' + to 5' x 5'	5' x 5' + to 6' x 6'	6' x 6' + to 7' x 7'	7' x 7' + to 8' x 8'
STRUCTURAL STEEL TUBE					
(cont.)					
6" x 6" x 3/16"		12'			
6" x 6" x 1/4"		12'	10'		
6" x 6" x 5/16"			12'		
6" x 6" x 3/8"				12'	
6" x 6" x 1/2"					10'
7" x 7" x 3/16"		12'	8'		
7" x 7" x 1/4"			12'		
7" x 7" x 5/16"				12'	
8" x 8" x 1/4"				12'	
4" x 3" x 5/16" 	8'				
5" x 3" x 3/16"	8'				
5" x 3" x 1/4"	10'				
5" x 3" x 5/16"	10'				
5" x 3" x 3/8"	10'	8'			
5" x 3" x 1/2"	12'	8'			
6" x 3" x 3/16"	8'				
6" x 3" x 1/4"	10'				
6" x 3" x 5/16"		8'			
6" x 3" x 3/8"	12'	10'			
6" x 4" x 3/16"	12'				
6" x 4" x 1/4"	12'	10'			
6" x 4" x 5/16"		12'	8'		
6" x 4" x 3/8"			10'		
6" x 4" x 1/2"			12'	8'	

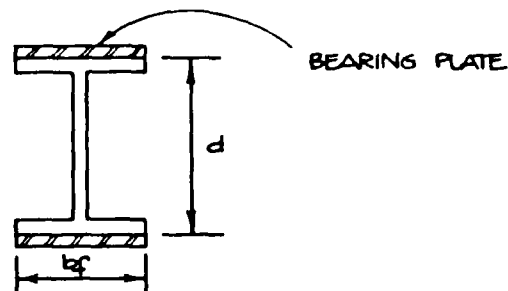
* minimum shore spacing should not be less than 30" (2.5') on center under most austere conditions.

TABLE A-1: SHORE DESIGNATION (contd)

STRUCTURAL TYPE AND DIMENSIONS 	MAXIMUM SHORE LENGTH - FEET				
	TYPE A		TYPE B		TYPE C
	A1	A2	B1	B2	C1
	* to 4' x 4'	4' x 4' to 5' x 5'	5' x 5' to 6' x 6'	6' x 6' to 7' x 7'	7' x 7' to 8' x 8'
STRUCTURAL STEEL TUBE					
(cont.) 7" x 5" x 3/16" 7" x 5" x 1/4" 7" x 5" x 5/16" 7" x 5" x 3/8"		12' 12'	10' 12' 12'	10'	
8" x 4" x 1/4" 8" x 4" x 5/16" 8" x 4" x 3/8"		12'	8' 12' 12'	8'	
8" x 6" x 1/4" 8" x 6" x 5/16"			12'	12'	
STEEL WIDE FLANGE BEAMS					
M5-18.9 5" wide by 5" deep 	12'	8'			
M6-20 6" wide by 6" deep	12'	10'			
W5-16 5" wide by 5" deep	12'				
W5-19 5" wide by 5 1/8" deep	12'	8'			
W6-16 4" wide by 6 1/4" deep	8'				
W6-18 6" wide by 6" deep	12'				
W6-20 6" wide by 6 1/4" deep	12'	10'			
W6-25 6 1/8" wide by 6 3/8" deep		12'	8'		
W8-24 6 1/2" wide by 7 3/8" deep		12'	8'		
W8-28 6 1/2" wide by 8" deep			12'		

* minimum shore spacing should not be less than 20" (2.5') on centers under most austere conditions.

TABLE A-2: BEAM REQUIREMENTS, POST AND BEAM SHORING



SHORE CLASS (FROM MAIN TEXT)	STEEL BEAM DESIGNATION	LIMITING BEAM DIMENSIONS			LENGTH (INCHES) OF BEARING PLATE (MINIMUM)
		BEAM DEPTH - INCHES		MINIMUM BEAM FLANGE WIDTH INCHES b_f	
		MINIMUM d	MAXIMUM d		
TYPE A					
A1	W8 x 35	8 $\frac{1}{8}$	9	8	6 $\frac{1}{2}$
A1	W10 x 33	9 $\frac{3}{4}$	11 $\frac{3}{8}$	8	8 $\frac{1}{2}$
A1	W12 x 27	12	14 $\frac{3}{8}$	6 $\frac{1}{2}$	7
A1	W14 x 26*	13 $\frac{7}{8}$	14 $\frac{3}{4}$	5	5 $\frac{1}{2}$
A1	W16 x 26	15 $\frac{5}{8}$	16 $\frac{3}{8}$	5 $\frac{1}{2}$	5 $\frac{3}{4}$
A2	W10 x 60	10 $\frac{1}{4}$	11 $\frac{3}{8}$	10 $\frac{1}{8}$	7 $\frac{3}{4}$
A2	W12 x 50	12 $\frac{1}{4}$	13 $\frac{3}{8}$	8 $\frac{1}{8}$	8 $\frac{3}{4}$
A2	W14 x 43	13 $\frac{3}{8}$	14 $\frac{3}{4}$	8	11 $\frac{1}{2}$
A2	W16 x 40*	16	16 $\frac{3}{8}$	7	11 $\frac{1}{2}$
A2	W18 x 40	17 $\frac{7}{8}$	18 $\frac{1}{2}$	6	11 $\frac{1}{4}$
TYPE B					
B1	W12 x 84	12 $\frac{1}{2}$	14 $\frac{3}{8}$	12 $\frac{1}{8}$	9 $\frac{1}{4}$
B1	W14 x 74	14 $\frac{1}{4}$	14 $\frac{3}{4}$	10 $\frac{1}{8}$	10 $\frac{1}{2}$
B1	W16 x 71	16 $\frac{1}{8}$	16 $\frac{3}{8}$	8 $\frac{1}{2}$	9 $\frac{1}{2}$
B1	W18 x 60	18 $\frac{1}{4}$	18 $\frac{1}{2}$	7 $\frac{1}{2}$	12
B1	W21 x 55*	20 $\frac{3}{4}$	21 $\frac{1}{2}$	8 $\frac{1}{4}$	13 $\frac{3}{4}$
B1	W24 x 55	23 $\frac{1}{2}$	24 $\frac{3}{4}$	7	12 $\frac{3}{4}$
B2	W18 x 90	18 $\frac{1}{8}$	19 $\frac{1}{2}$	11 $\frac{3}{4}$	13 $\frac{1}{4}$
B2	W21 x 90	21 $\frac{1}{8}$	21 $\frac{1}{2}$	9	11
B2	W24 x 70*	23 $\frac{3}{8}$	24 $\frac{3}{4}$	9	16
B2	W27 x 84	26 $\frac{3}{4}$	27 $\frac{1}{4}$	10	15
TYPE C					
C1	W21 x 127	21 $\frac{1}{4}$	21 $\frac{1}{2}$	13	14 $\frac{3}{4}$
C1	W24 x 110	24 $\frac{1}{8}$	24 $\frac{3}{4}$	12	17 $\frac{3}{4}$
C1	W27 x 102	27 $\frac{1}{8}$	27 $\frac{1}{4}$	10	17 $\frac{1}{2}$
C1	W30 x 99*	29 $\frac{3}{8}$	30 $\frac{3}{8}$	10 $\frac{1}{2}$	17 $\frac{3}{4}$

* optimum section based on weight per foot.

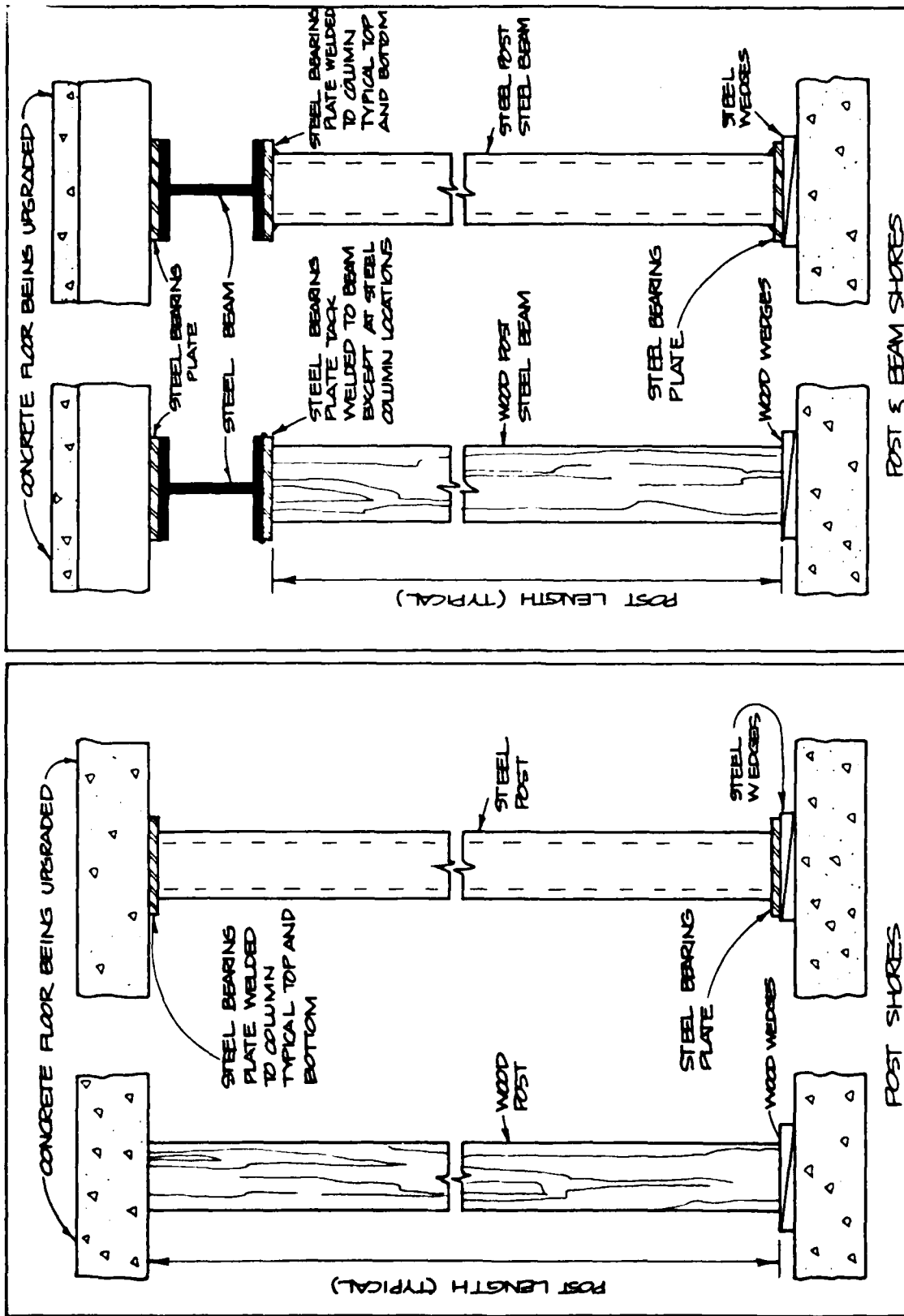
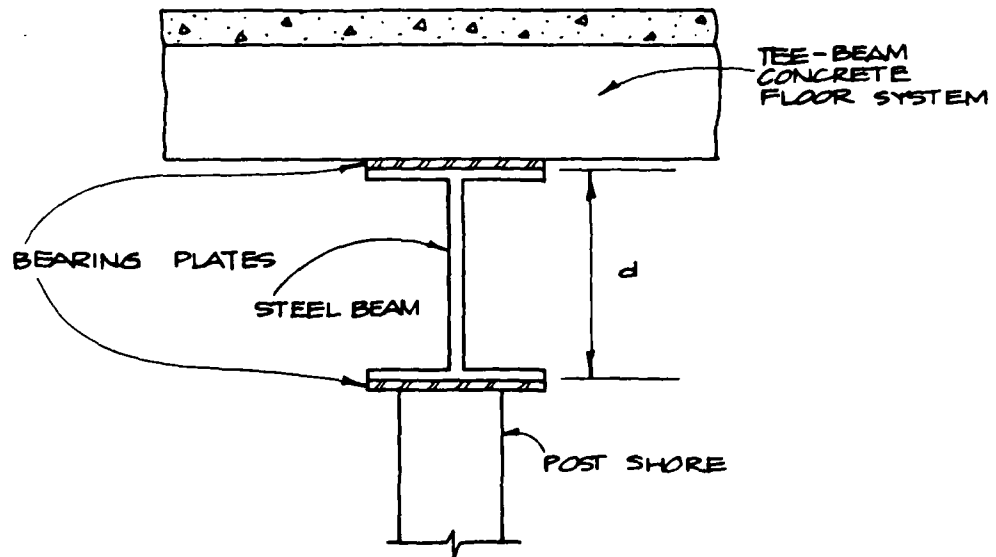
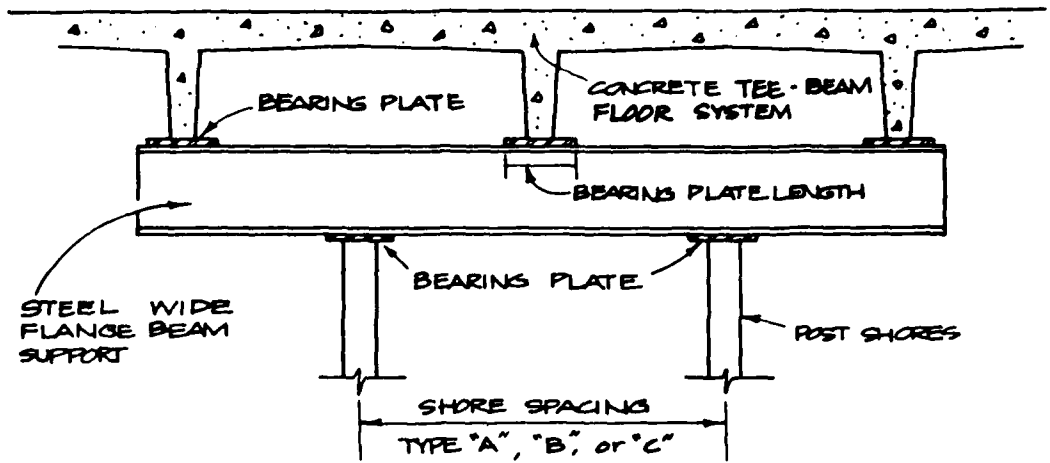


Fig. A-1. Post Shore Details.



NOTE: BEARING PLATES MUST BE USED BETWEEN BEAM AND SUPPORTED FLOOR MEMBERS ABOVE, AND AT BOTH ENDS OF POST SHORES.

Fig. A-2. Post and Beam Shoring System Details.

RESOURCE LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Posts, steel or wood		
2. Beams, steel		
3. Nails		
4. Hammer		
5. Saw		
6. Wedges		
7. Tape measure/yardstick, etc.		
8.		
9.		
10.		

RESOURCE LIST

<u>Required</u>	<u>Quantity</u>	<u>Available</u>
1. Posts, steel or wood		
2. Nails		
3. Hammer		
4. Saw		
5. Wedges		
6. Tape measure/yardstick, etc.		
7.		
8.		
9.		
10.		

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SUPPLEMENTARY

INFORMATION

AD-A102631

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12 March 1982

INDUSTRIAL PROTECTION MANUAL, SSI Report No. 8011,
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Contract No. EMW-C-0154, Work Unit 1124E, June 1981.
AD Number: A 102631

The attached sheets are to replace two pages in Booklet 10 of the above referenced Industrial Protection Manual, which was distributed in July 1981.

The replacement material is intended to clarify the application of Figure 13 to the selection of appropriate closures for superfluous openings in below-grade expedient shelters and accessways in shelter entry structures.

STEP 5: Assess Shelter Closures and Access Alternatives

Whenever adapting or converting existing structures to key worker shelter space, closures will generally be required for existing openings. Shelters will need to be below ground to provide the blast and radiation protection required at 40 psi.

Closures will serve two purposes, to seal superfluous openings and to protect accessways. For superfluous openings, such closures may be oriented anywhere from horizontal to vertical, and to seal out radiation (as well as blast) several feet of earth cover, or an equivalent substitute, will be required. To provide accessways, special blast and radiation resistant shelter entry structures will be required.

Shelter Entry Structures

At 40 psi, special shelter entry structures are required to provide blast and radiation protection that existing entries cannot. Because of the nature of airblast waves when reflected directly off vertical surfaces, accessway closures must either be flush with a horizontal section of the ground surface, be a part of a vertical area that is small in extent (e.g., as in the shelters at the tops of pages 26 through 28 - perhaps 9 feet high and 18 feet across the base), or be sufficient to resist a peak (reflected) overpressure of 146 psi if installed in the face of a structure or cliff that is extensive (i.e., tens of feet high and across).

Suitable entry structures of wood, and of concrete or corrugated metal pipe, and closures for expedient shelter accessways, are shown in Figures 8 through 11. Note these particular entryway structures are designed to be below ground and the entryway closures to be flush with the horizontal surface.

Non-accessway Closures

Any basement structure (or expedient shelter) to be upgraded may have a stairway, windows, doors, ventilation ducts or other openings that must be rendered blast and radiation proof. These openings can be bridged using a variety of readily available materials (e.g., wood, steel), then covered with earth for radiation protection. Examples of wood materials that may be used are fence posts, spare power poles (cut up), railroad ties, solid core doors, and wood beam and plank pieces. Steel plate and rolled beam sections, though less readily available, may also be used. Table 1 (page 44) lists materials that may be considered as alternatives for closures.

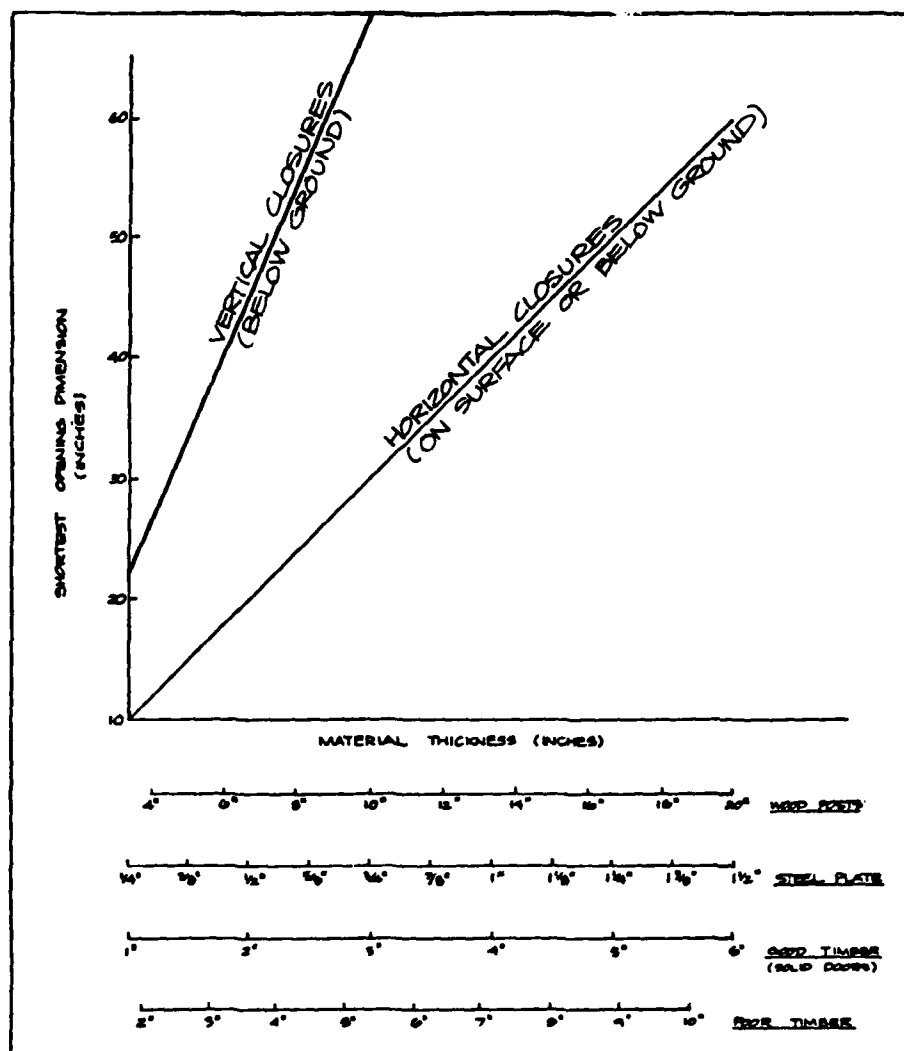


Fig. 13. Material Thickness Required to Close Various Openings (at the 40 psi ground range).